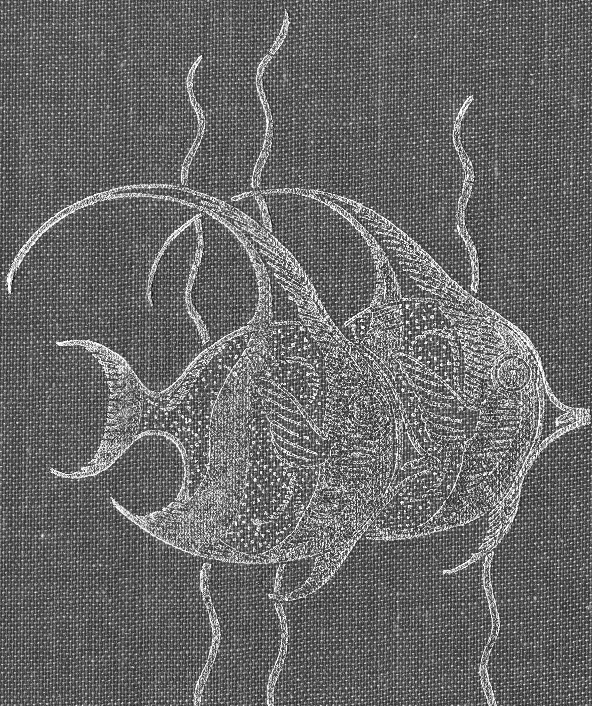
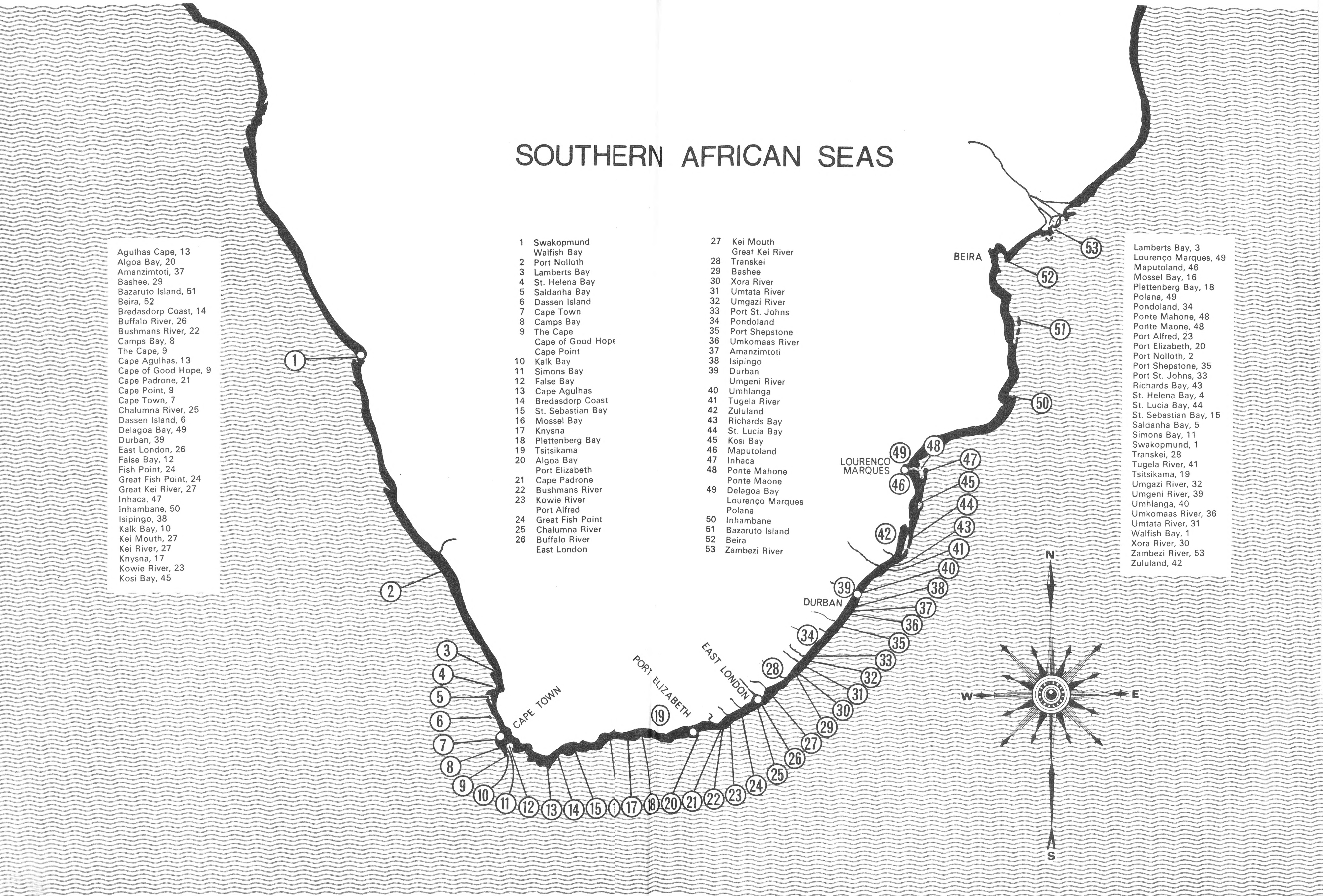
ICHTHYOLOGICAL PAPERS

OF J. L. B. SMITH 1931-1943



VOLUME 2


SOUTHERN AFRICAN SEAS
Agulhas Cape, 13
Algoa Bay, 20
Amanzimtoti, 37
Bashee, 29
Bazaruto Island, 51
Beira, 52
Bredasdorp Coast, 14
Buffalo River, 26
Bushmans River, 22
Camps Bay, 8
The Cape, 9
Cape Agulhas, 13
Cape of Good Hope, 9
Cape Padrone, 21
Cape Point, 9
Cape Town, 7
Chalumna River, 25
Dassen Island, 6
Delagoa Bay, 49
Durban, 39
East London, 26
False Bay, 12
Fish Point, 24
Great Fish Point, 24
Great Kei River, 27
Inhaca, 47
Inhambane, 50
Isipingo, 38
Kalk Bay, 10
Kei Mouth, 27
Kei River, 27
Knysna, 17
Kowie River, 23
Kosi Bay, 45
1 Swakopmund
Walfish Bay
2 Port Nolloth
3 Lamberts Bay
4 St. Helena Bay
5 Saldanha Bay
6 Dassen Island
7 Cape Town
8 Camps Bay
9 The Cape
Cape of Good Hope
Cape Point
10 Kalk Bay
11 Simons Bay
12 False Bay
13 Cape Agulhas
14 Bredasdorp Coast
15 St. Sebastian Bay
16 Mossel Bay
17 Knysna
18 Plettenberg Bay
19 Tsitsikama
20 Algoa Bay
Port Elizabeth
21 Cape Padrone
22 Bushmans River
23 Kowie River
Port Alfred
24 Great Fish Point
25 Chalumna River
26 Buffalo River
East London
27 Kei Mouth
Great Kei River
28 Transkei
29 Bashee
30 Xora River
31 Umtata River
32 Umgazi River
33 Port St. Johns
34 Pondoland
35 Port Shepstone
36 Umkomaas River
37 Amanzimtoti
38 Isipingo
39 Durban
Umgeni River
40 Umhlanga
41 Tugela River
42 Zululand
43 Richards Bay
44 St. Lucia Bay
45 Kosi Bay
46 Maputoland
47 Inhaca
48 Ponte Mahone
Ponte Maone
49 Delagoa Bay
Lourenço Marques
Polana
50 Inhambane
51 Bazaruto Island
52 Beira
53 Zambezi River
Lamberts Bay, 3
Lourenço Marques, 49
Maputoland, 46
Mossel Bay, 16
Plettenberg Bay, 18
Polana, 49
Pondoland, 34
Ponte Mahone, 48
Ponte Maone, 48
Port Alfred, 23
Port Elizabeth, 20
Port Nolloth, 2
Port Shepstone, 35
Port St. Johns, 33
Richards Bay, 43
St. Helena Bay, 4
St. Lucia Bay, 44
St. Sebastian Bay, 15
Saldanha Bay, 5
Simons Bay, 11
Swakopmund, 1
Transkei, 28
Tugela River, 41
Tsitsikama, 19
Umgazi River, 32
Umgeni River, 39
Umhlanga, 40
Umkomaas River, 36
Umtata River, 31
Walfish Bay, 1
Xora River, 30
Zambezi River, 53
Zululand, 42
BEIRA
LOURENCO MARQUES
DURBAN
EAST LONDON
PORT ELIZABETH
CAPE TOWN
N
S
W
E

J. L. B. SMITH

ICHTHYOLOGICAL PAPERS

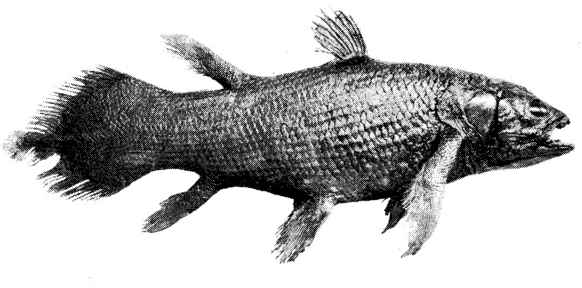
1931—1943

J. L. B. SMITH

ICHTHYOLOGICAL PAPERS
1931—1943

Vol. 2

Edited by
Margaret M. Smith



PUBLISHED BY THE J. L. B. SMITH INSTITUTE OF ICHTHYOLOGY
RHODES UNIVERSITY · GRAHAMSTOWN
1969

Printed by Cape & Transvaal Printers Ltd., Cape Town.

VOLUME 2

Contents

Acknowledgements

I wish to express my appreciation:

for the permission granted by the following to reproduce the papers in this volume:

1. The Director, Albany Museum, Grahamstown;
2. The Editor, Royal Society of South Africa, Cape Town;
3. The Acting Director, Natal Museum, Pietermaritzburg;
4. The Editor, *Nature*, London;

to Miss M. Igglesden for many hours of work compiling the index;

to the staff of the Department of Ichthyology for their encouragement and assistance.

Margaret M. Smith,
Grahamstown.
June, 1968.

Transactions of the Royal Society of South Africa. Vol. XXV. Part IV. pp. 389–390. Pl. X. March, 1938.

AN INTERESTING EARLY POST-LARVAL STAGE OF THE "GALJOEN."

By J. L. B. Smith.

(With Plate X.)

(Read August 18, 1937.)

Family Dichistiidae.

Dichistius capensis C. & V.

1935. Smith, J. L. B., Trans. Roy. Soc. S.A., vol. xxiii, pt. iii, p. 269. pl. xiii.

The common "Galjoen," *D. capensis* C. & V., is one of the best-known angling fishes of the Cape, but little or nothing is known of its breeding habits or developmental stadia. Recently a very young specimen, early post-larval, has been secured, which is of interest in showing that fairly extensive developmental changes occur during growth to the adult stage.

A brief description of the specimen is as follows:—

Depth 2·9, length of head 3·1 in body length. Eye 2·5, and snout 5·5 in length of head. Preorbital very shallow, about 6 in eye. Snout rather blunt, with an angular convexity before the nostrils. Dorsal profile from nape almost horizontal. Preopercle margin strongly serrate, serrae large flat spines round angle. Two small opercular and one sub-opercular spines. Lower jaw projects, mouth very oblique. Teeth incisiform, apically acute (Pl. X, *a*).

D X, 18, 4th spine longest, equal to eye: 8th–10th spines subequal, $\frac{2}{3}$ of 4th. First ray longer than last spine, rays increase to the 3rd, longest, 1·2 in eye, thereafter decrease slowly, making anterior part of soft fin a gently rounded lobe. A III, 14, spines fairly short. 3rd and 4th rays subequal, longest, equal to eye, remainder graduated shorter. Base of anal half base of dorsal, 1·4 in head. Pectoral 1·4, ventral 1·3 in head, latter reaches vent. Caudal almost truncate, very slightly emarginate.

Scales very thin, impossible to count.

Silvery blue, with five dark cross bars becoming darker after death, the first over the nape, wider than interspaces. Anterior 7 dorsal spines in a dark patch. A dark blotch on anterior dorsal rays, and on anterior

anal rays. Distal third of ventrals dark, a dark spot on upper caudal lobe. Pectoral and most of caudal light.

Length.—22 mm. Taken in a rock-pool near the Bushmans River mouth, west of Port Alfred, in September 1936.

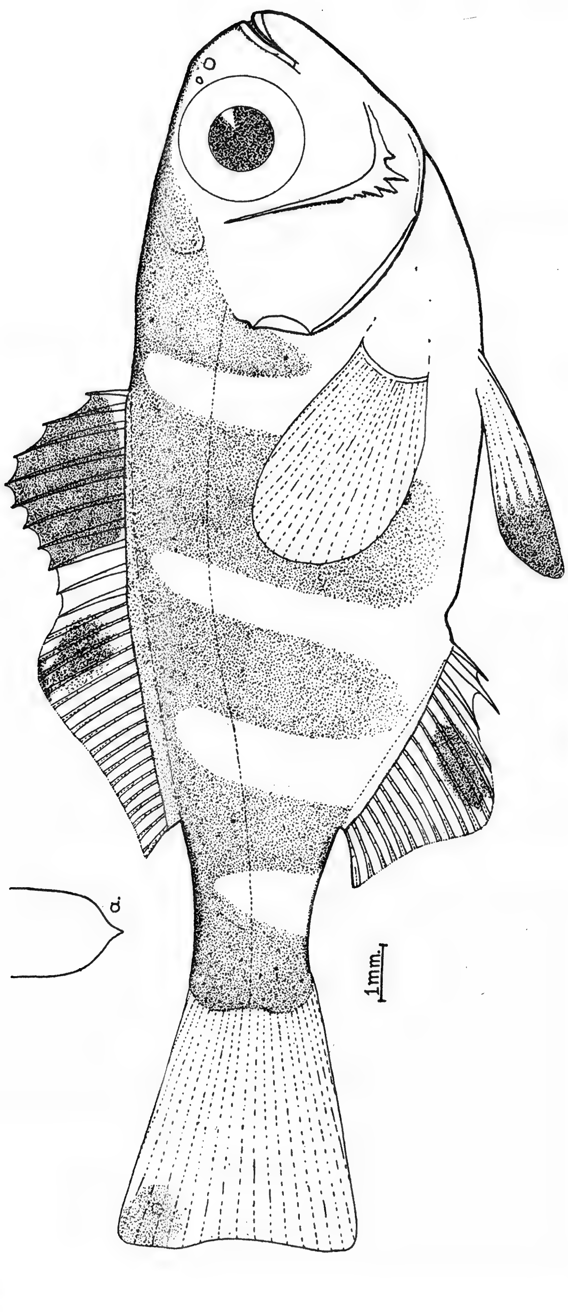
It has previously been observed (Smith, *loc. cit.*, p. 274) that *Dichistius* probably spawns about August. The small specimen now described was therefore likely only a month or six weeks old, representing a very early post-larval stage.

Interesting features are the spines on the preopercle, the shallow body, the truncate caudal, and the anteriorly relatively low soft dorsal and anal. It is noteworthy that the spinous dorsal is of much the same shape and proportions as in the adult. The sharply cuspidate teeth are remarkable: even in mid-juvenile stadia the teeth are more or less truncate, almost chisel-edged.

In general outline the fish resembles a young Stromateid, but the dorsal and anal fin formulae alone leave no doubt of the identity of the specimen.

I wish to express my gratitude to the Research Grant Board of South Africa (Carnegie Fund) for financial assistance.

ALBANY MUSEUM,
GRAHAMSTOWN,
August 1937.



Dichistius capensis C. & V. Juv.
(22 mm. Length.)

Transactions of the Royal Society of South Africa. Vol. XXVI.
Part III. pp. 225–305. Pls. XVIII–XXIX. June, 1938.

THE SOUTH AFRICAN FISHES OF THE FAMILIES SPARIDAE AND DENTICIDAE.

By J. L. B. SMITH.

(With Plates XVIII–XXIX and twenty-five Text-figures.)

(Read June 16, 1937.)

It is only within the last two decades that the classification of the rich marine ichthyfauna of South Africa has been placed on any secure footing. For that we are indebted chiefly to the labours of Gilchrist and his co-workers, and later and more fully to the comprehensive and excellent work of Barnard.

Although this earlier work, especially that of Barnard, was of high standard, the field covered was so vast that critical and detailed study of each group was impossible. It is becoming increasingly obvious that a great part of the earlier work will have to be revised.

In the wake of those pioneers have come, within the last few years, several other workers who have directed their attention to South African fishes, and who have made very considerable changes, both taxonomic and nomenclatorial, in line with the more searching analysis characteristic of modern work.

The South African species of the family Sparidae have notably stood in need of critical revision. Although among them are many of considerable economic and taxonomic significance, yet the relationships between the species have never been properly investigated. Generic limits have been sadly lacking in uniformity; in some cases monotypic genera have been defined within limits which are very narrow by contrast with others, which have embraced forms so widely divergent and polymorphous as to be almost without parallel in any other families. Also there has been wide divergence of opinion about genera and generic limits among those who have worked upon our Sparid fishes. That particular work has in most cases been only a part of a larger treatise on the ichthyfauna of a whole region, so that the treatment of any individual group has been necessarily somewhat uncritical. A considerable amount of work has been done also elsewhere on the Sparidae, but a comprehensive revision, based on a world collection, is very badly needed. A work of that nature cannot

be carried out from South Africa, since only a few of our species appear to fall into cosmopolitan genera, while many important genera are not represented in our area.

The aim of the present investigation has been to place the taxonomy of the South African species on as sound a basis as possible. Fortunately a relatively large number of South African Sparid fishes appear to be endemic, and a number of those fall into purely endemic genera, whereby the problem of their relationships is considerably simplified. At the same time it is realised that the validity of the present arrangement can be established only by some worker who has at his disposal an adequate world collection, and who has access to orthotypes and early literature not available here.

What may be accepted as the first really practical definition of the family Sparidae was given by Regan (Ann. Mag. Nat. Hist., 1913 (8), vol. xii, p. 124). He there indicated the feature common to all fishes of that family as then recognised, *i.e.* the external overlapping of the maxilla by the extremity of the premaxilla (a character also of the related Maenidae, which differ chiefly in the very feeble dentition). Actually in Spariform fishes the distal extremity of the premaxilla has in its upper surface some form of groove of varying size and shape. In that groove rests a part of the lower edge of the distal portion of the maxilla. When the jaws are protruded or retracted, the premaxillary groove slides along the lower maxillary edge. The arrangement must contribute materially to the strength of the jaws. (See text-figs. 1 and 2.)

Regan at that time (*loc. cit.*) recognised 10 genera of Sparid fishes in South Africa, viz. *Dentex* Cuvier, *Pagellus* Cuvier, *Cantharus* Cuvier, *Box* Valenciennes, *Crenidens* Valenciennes, *Sparus* Linnaeus, *Pagrus* Cuvier, *Diplodus* Rafinesque, *Chrysophrys* Quoy and Gaimard, and *Gymnocrotaphus* Günther, of which the latter only was endemic (and monotypic).

Regan distinguished *Dentex* from other genera in that parapophyses are present from only the third precaudal vertebra and the first rib is sessile, while the rest have parapophyses on all the precaudals and none of the ribs sessile.

Barnard (Ann. S.A. Mus., 1927, vol. xxi, p. 683) recognised 39 species and 12 genera of Sparid fishes in South Africa: those of Regan (above, with *Caranthus* Barnard proposed to replace *Cantharus* Cuv., preoccupied) with the exception of *Chrysophrys* Q. and G. (which Barnard regarded as a synonym of *Pagrus* Cuv.), but with the addition of *Charax* Risso, *Boopsoidea* Castlenau, and *Tripterodon* Playfair. Barnard has since (see Smith, Trans. Roy. Soc. S. Afr., 1935, vol. xxii, p. 308) agreed that *Tripterodon* does not fall in the Sparidae, thus reducing the number of genera recognised to 11.

Fowler (U.S. Nat. Mus. Bull. 100, 1933, vol. xii, p. 64) recognised 34 species and 11 genera of Sparid fishes in South Africa: *Dentex* Cuv., *Gymnocranius* Klunzinger, *Argyrops* Swainson, *Sparus* Linn., *Boopsoidea* Cast., *Pagellus* Cuv., *Diplodus* Raf., *Puntazzo* Bleeker (= *Charax* Risso), *Sarpa* Cuvier (= *Box* Cuv. as defined by Barnard), *Spondyliosoma* Cantor (= *Caranthus* Barnard), and *Gymnocrotaphus* Gnthr.; together with numerous subgenera. Fowler's classification diverges widely from that of Barnard. He placed *Crenidens* Val. in the Girellidae, a diagnosis which is demonstrably invalid (*vide infra*). He recognised *Gymnocranius* Klunz. as distinct from *Dentex* Cuv., and *Argyrops* Swnsn. as separate from either *Sparus* Linn. or *Pagrus* Cuv., distinctions not accepted by Barnard at full generic rank. At the other extreme, Fowler grouped together in the single very wide genus *Sparus* Linn. (as by him defined) those species regarded by Barnard as falling in *Sparus* Linn. and in *Pagrus* Cuv. Actually Fowler did not accept any South African species as falling in *Pagrus* Cuv., an opinion which is probably correct. On the other hand, his wide limits for the genus *Sparus* Linn. are not in accord with most other work and are not accepted here.

Norman (Ann. S.A. Mus., 1935, vol. xxxii, pp. 5 ff.) has shown that the species accepted by Barnard as falling in *Caranthus* Brnrd. (and in *Spondyliosoma* Cantor by Fowler) actually represent 2 genera, viz. *Spondyliosoma* Cantor and *Pachymetopon* Günther, and a related species has been made the type of a new genus, *Polyamblyodon* Norman. *Pachymetopon* Gnthr. had been placed by Barnard in the Girellidae, and by Fowler in the Kyphosidae, but the relations of the maxillary bones have shown it to be a Sparid genus.

Of the above works that of Fowler is the most comprehensive, since it deals with almost the whole of the Sparid fishes of the Indo-Pacific and is of value in containing most of the references to Indo-Pacific species. Fowler's opinions, while diverging widely from those of Barnard (and of Norman), must receive consideration as emanating from a worker of great experience. At the same time his work on the Sparid fishes has obviously not been compiled with the care and accuracy that one might expect from so eminent a worker, and its value is much diminished thereby. In many instances inconsistencies render his keys to genera and species almost valueless. On general taxonomic grounds criticism may chiefly be directed against Fowler's grouping together in *Sparus* Linn. numerous widely divergent forms which cannot possibly be congeneric. That arrangement was probably due to lack of material and of information.

Norman also has done a considerable amount of work on South African fishes. Recently (*loc. cit.*) he has investigated the relationships of certain of our Scatharine fishes. His classification, though diverging widely from

what has hitherto been current, is accepted as it stands, though in parts the evidence on which it is based is rather slender.

These widely divergent and almost irreconcilable classifications have left our Sparidae in a state of chaos, which cannot be remedied save by a critical revision *de novo*. One of the chief aims of the present investigation has been to balance the genera so that the limits shall be of approximately equal extent. This has resulted in what may at first sight appear as an unnecessarily extensive division of established genera. Nevertheless it is believed that the arrangement proposed is sound, and consistent with the trend of modern analysis. The scheme is based not only upon the more important taxonomic characters, but also upon an extensive ecological study of our Sparid fishes.

The 41 South African species are here divided into 23 genera,* of which 7 are proposed as new, and 6 are revived after having been sunken as synonyms or as subgenera. Twelve are monotypic, and of those 6 appear to be endemic. Three genera have only 1 species in South Africa but are represented elsewhere.

To assist in the correlation of species from South Africa with those accepted as being in the same genus but found in other parts, the procedure has been instituted of naming from among the South African species one as the *regional genotype*.

In this work only those Sparid species which occur in the waters of the south and eastern coasts of South Africa have been included. The cold waters which wash the western shore of South Africa act as a barrier to prevent almost entirely the intermingling of the Atlantic with the Indo-Pacific forms which are characteristic of the south and eastern coasts of our region. The few species listed only from the northern region of the west coast are not typically South African, nor are they to be found in any collections in South Africa. Strictly, they belong more to the northern Atlantic or to the Mediterranean region, and their inclusion in the South African marine ichthyfauna list has been more of a convention than anything else.

It is remarkable how few systematists have paid attention to the nature of scales. Actually they merit detailed study and are often of great assistance in differentiation. Fowler generally gives a description of the nature of the scales for each species, but does not state from what part of the body the described scale has been taken. It is usual to find that while a scale from one special position on the body varies but little between

* South African marine fishes generally appear to fall into numerous genera, many monotypic or with only one or two representatives in our area. In the Gadidae 12 species fall into 10 genera, in the Brotulidae 11 species into 11 genera, while the 45 South African species of "Flat-fishes" fall into 30 well-defined genera.

specimens of any one species, yet the shape and form of the scales on most fishes vary widely on different parts of the body of any one specimen. Any figure or description of a scale is therefore of much diminished value in the absence of a statement indicating the exact position on the body from which it was taken.

In the Sparidae both cycloid and ctenoid scales are present, sometimes both on one species. Generally in that family the ventral scales are more strongly ctenoid than those on the dorsal surface; in some cases the dorsal scales are cycloid and those on the ventral surface ctenoid. Mostly the lateral line scales of Sparid fishes have a more or less strangulated (hour-glass-shaped) tubule, behind which, save in only a few species, are found pores, either a pair, or a double radiating series.

It is of interest to note that at least some of the genera, as outlined in this work, receive support for their validity from the nature of the scales of the species, *e.g.* the scales of the species in each of the closely related genera *Austrosparus* n.g., *Acanthopagrus* Peters, and *Diplodus* Raf. on comparison show definite group similarities. In *Austrosparus* the lateral line scales are cycloid, with heavy tubules and radiating series of pores behind. Those of *Acanthopagrus* are weakly ctenoid, the tubule is much more slender, and at most only two fine pores show behind. In *Diplodus* the lateral line scales are strongly ctenoid, and there are either several transverse pores, or the tubule bifurcates with very fine branches. (See Plates XVIII–XXIII.)

Enlarged photographs of the scales of most species will be found in Plates XVIII–XXIX. One scale from above the lateral line, one lateral line tubular scale, and one from below the lateral line, each from an exactly defined position, are figured for each species. Also the exact size of the scale and of the specimen from which it was taken are given in each case.

It is desirable that dimensional limits about which there may be any doubt should be defined precisely. The following indicates what have been used in the present case:—

Length of Body.—From snout tip to the base of the mid-caudal rays (often obscured by scaling).

Length of Head and of Snout.—Not measured in profile, but in a straight line in each case; hence the dimensions of the head may appear to vary between the text and the figures, in which latter the length of the head would have to be measured in profile.

Length of Fins.—Measured from the body to the tip of the fin held out from the body.

Lateral Line Scales.—Tubular scales from the origin of the lateral line at the shoulder to the base of the mid-caudal rays (see Length of Body). Tubular scales on the caudal rays are not included.

Lateral transverse series are counted obliquely back from just before the origin of the dorsal fin.

Species of which no accurate drawing exists have been figured.

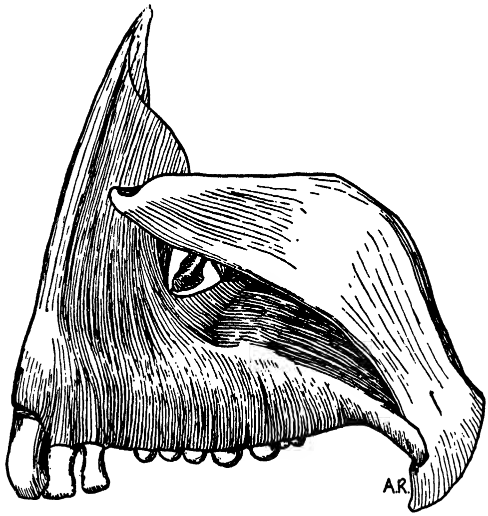


FIG. 1.—Maxilla and premaxilla of a typical Sparid fish. (*Austrosparus auriventris* Peters.)

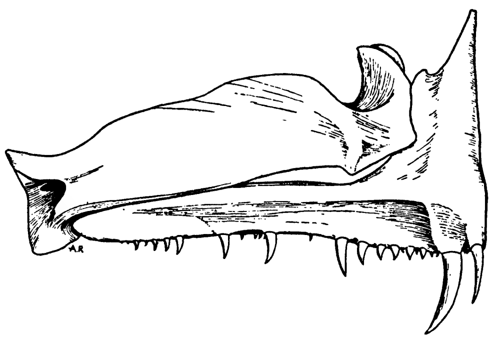


FIG. 2.—Maxilla and premaxilla of a typical Denticid fish. (*Polysteganus argyrozona* Valenciennes.)

Those figures have been prepared with chief regard to strict dimensional accuracy. In the case of any very large or very small specimen a suitably reduced or enlarged photograph has been employed from which to plot the outline, etc. In other cases a method has been used which ensures an accurate outline, points of insertion of fins, etc. This is briefly described below, since it may prove of assistance to others. Along the margins of a

rectangular board 15 by 12 inches stout pins are driven in exactly 1 cm. apart and numbered serially. On the board itself are drawn connecting lines opposite pins. The fish is then laid on this board and ordinary sewing cotton woven tightly across and along from the pins so as to form a network of 1 cm. squares (corresponding with the lines on the board) over the whole body. On a piece of Bristol board are drawn squares of size suitable to any reduction or enlargement required, and the outline, etc. plotted on this from the squares over the specimen. Naturally the method is most suitable for compressed fishes, but may be applied to practically all forms.

The Sparidae as formerly accepted by most workers are here divided into two families, the Sparidae and the Denticidae. This appears to be justified both by internal and external structure, as well as by general habits and habitat.

The following key indicates the main lines of division between the two families:—

1. All precaudal vertebrae with parapophyses; no ribs sessile. Premaxillary rami rather deep and heavy, especially proximally, and not much longer, if at all, than pedicels (see fig. 1). Dentition sectorial, or rapto-tritorial, or secto-tritorial. Teeth never all acute, conical teeth when present always accompanied by molariform teeth. Typically inhabit shallow water, surf, or estuaries, rarely exclusively predatory . . . . *Sparidae.*
2. Precaudal vertebrae with parapophyses from the third, and the first rib sessile. Premaxillary rami rather slender and shallow, longer than pedicels (see fig. 2). Dentition primarily raptorial. Teeth all acute, anterior always typically caniniform or fanglike, large blunt molariform teeth never present. Typically inhabit deeper water than the Sparidae, do not enter the surf or estuaries save by accident. Almost exclusively predatory . . . . . *Denticidae.*

Family SPARIDAE.

Body compressed, or moderately compressed, elevated, oval or elongate-oval.

Mouth small or moderate, slightly to greatly protractile. Maxilla partly or entirely concealed beneath preorbital. Teeth various: conical and molariform together; or only incisiform; or incisiform and molariform teeth together may be present in each jaw; occasionally villiform teeth occur in a band behind the outer teeth. No palatal teeth in South African species. Outer teeth typically implanted in sockets; replacement by vertical succession.

Gills 4, a slit behind the 4th. Gill-rakers either tubercular, or lanceolate, relatively few. Gill-membranes free from isthmus. Pseudobranchiae

present. Air-bladder simple, or bifurcated, with or without caudal prolongations. Pyloric caeca few.

Dorsal single, seldom deeply notched. 3 anal spines, the 2nd sometimes enlarged. Ventrals of a spine and 5 rays with axillary scale. Caudal always forked or emarginate.

Scales cycloid, or weakly or strongly ctenoid, or variously mixed; usually scales on ventral surface more strongly ctenoid than dorsal scales. Soft dorsal and anal naked with basal sheath, or lightly or densely scaly basally.

Skull typically with well-developed occipital and parietal crests. Frontals sometimes produced forward acutely. Premaxillary pedicels rarely reaching frontals, seldom as long as rami. The upper margin of the distal extremity of the premaxilla with some form of groove, in which rests part of the lower surface of the maxilla; a part of the extremity of the premaxilla always overlaps the maxilla externally. Dentaries usually deep and heavy, occasionally cavernous and of light structure. (*Pterogymnus.*) A strong subocular shelf developed forward from the second suborbital. Vertebrae constantly 24 (10 + 14). All precaudals with parapophyses and no sessile ribs.

The South African species fall into three fairly well-defined groups, each of which is for convenience of key simplification here accorded subfamily rank.

The South African species of the family are mostly prolific, and many occur in such numbers as to be of great economic significance. They are mostly shore fishes, a few entering or frequenting tidal estuaries. The flesh of most species is highly esteemed.

Key to the Subfamilies of the Sparidae.

1. A group of enlarged antero-exterior teeth in each jaw, not continued laterally; if conical, not more than 8; if incisiform, not more than 9 in the front of the lower jaw . . . . *Sparinae.*
2. No separate group of enlarged anterior teeth. If outer series at all enlarged, then usually continued laterally, with more than 8 conical, or more than 9 incisiform in the outer series in the lower jaw.
   - A. Teeth of outer series slight and conical, with villiform teeth in a band anteriorly . . . . *Pagellinae.*
   - B. Teeth of outer series incisiform, even when acute or lanceolate . *Scatharinae.*

The classification of the Sparidae here proposed is outlined below. Genera and species marked * are endemic.

I. Sparinae.

Genus.	*Species.*
Acanthopagrus Peters.	*berda* Forskäl (type).
	bifasciatus Forskäl.
Austrosparus n.g.	*globiceps* C. and V.* (type).
	sarba Forskäl.
	auriventris Peters.
Sparodon n.g.*	*durbanensis* Cast.* (type).
Puntazzo Bleeker.	*puntazzo* Cetti (type).
Diplodus Raf.	*sargus* Linn. (regional genotype).
	trifasciatus Raf.
Argyrops Swnsn.	*spinifer* Forskäl (type).
	filamentosus Val.
Pterogymnus n.g.*	*laniarius* Cuv.* (type).
Cymatoceps n.g.*	*nasutus* Cast.* (type).
Chrysoblephus Swnsn.*	*gibbiceps* Cuv.* (type).
	lophus Fowler.*
	cristiceps Cuv.*
	anglicus G. and T.*
	puniceus G. and T.*
	laticeps Cuv.*
Porcostoma n.g.*	*dentata* G. and T.* (type).

II. Pagellinae.

Genus.	*Species.*
Pagellus Cuv.	*natalensis* Stndr. (regional genotype).
Lithognathus Swnsn.	*lithognathus* Cuv.* (type).
	mormyrus Linn.
Boopsoidea * Cast.	*inornata* Cast.* (type).

III. Scatharinae.

Genus.	*Species.*
Sarpa Bonap.	*salpa* Linn. (type).
Crenidens Val.	*crenidens* Forskäl (type).
Polyamblyodon * Norman.	*germanum* Barnard * (type).
Spondyliosoma Cantor.	*emarginat~~a~~um* Cuv. (regional genotype).
Pachymetopon * Gnthr.	*grande* Gnthr.* (type).
	blochii Val.*
	aeneum G. and T.*
	canescens Norman.*
	glaucum Norman.*
Gymnocrotaphus * Gnthr.	*curvidens* Gnthr.*

Subfamily SPARINAE.

Molariform teeth always present. Anterior teeth few, conical or incisiform, always in a separate group, enlarged, not continued laterally. Dentition rapto-tritorial, or secto-tritorial, powerful. Mouth moderate. Premaxilla usually deep and heavy; rami not much, if at all, longer than pedicels. Maxilla typically heavy, sometimes with acute produced infero-anterior process. Scales cycloid or ctenoid, or both. Soft vertical fins naked or scaly. Interorbital naked and porous, or scaly. Preopercle flange naked, or partly or wholly scaly. Cheeks scaly. Dorsal never deeply notched between spinous and soft portions.

Other characters as outlined for the family.

Mostly shore fishes, some entering or even commonly found in estuaries and lagoons. No species graminivorous, usually otherwise more or less omnivorous, carnivorous when occasion offers, but the chief foods are mollusca and crustacea.

Only one species (*nasutus* Castlenau) grows to a large size, most others rarely exceed moderate size. Almost all are game fishes, but are strong and vigorous rather than speedy. The flesh of all species is of good texture and flavour, and this group is of considerable economic significance in South Africa.

The body colour is either silvery, olive, or some shade of red, and does not vary widely among the species in any one genus.

The nature of the interorbital region has proved of very great significance in the Sparinae. According as it is naked or scaly, so are the genera and species very sharply divided; a division rendered all the more significant since it is confirmed by numerous other features such as dentition, group colour, habits and habitat, etc. For example, the species of the group with naked interorbitals are silvery or olive in colour, frequently with dark cross-bars, and the preopercle flange is usually naked. Typically they inhabit shallow water, even surf, and commonly enter estuaries. Their anterior teeth are always incisiform, and the chief foods are mollusca and crustacea.

The species of the group with scaly interorbitals are red or reddish (one species only is black), and cross-bars are rarely present and then never dark or dusky. The preopercle flange is usually scaly. They are usually found in deeper water than those of the other group, and only in exceptional circumstances in the surf or in estuaries. The anterior teeth are always caniniform, and the species appear to be by choice carnivorous.

Key to South African Genera of the Sparinae.
(10 Genera; 20 Species.)

I. Scales on head not extending into the interorbital region.* Enlarged molars, if present, never of outer series. Anterior teeth usually incisiform. Ground colour silvery or olive, often dark cross-bars.

- A. Not more than 6 teeth in the anterior series in the upper jaw. Generally at least some scales above the lateral line cycloid.
  - X. Scales large, not more than 50 series. Soft dorsal and anal scaly at base. Lateral line scales ctenoid. Second anal spine enlarged. Dorsal spines strong . *Acanthopagrus.*
  - Y. Scales moderate to small, more than 55 series. Soft dorsal and anal naked, with low sheath. Lateral line scales cycloid. Second anal spine not or scarcely enlarged. Dorsal spines moderate or slender.
    - [*a*. Anterior teeth conical. Scales small, more than 70 series. All scales cycloid. Mediterranean and North-West Africa . . *Sparus.*]
    - *b*. Anterior teeth incisiform. Scales moderate, 55–65 series. Scales on lower half of body ctenoid. South Africa and Indo-Pacific.
      - i. Incisors subequal. Pectorals longer than head. Frontals moderately broad, interorbital not twice eye . *Austrosparus.*
      - ii. Two median incisors in each jaw very much larger than others. Pectorals shorter than head. Frontals broad, interorbital more than twice eye . *Sparodon.*
- B. More than 6 teeth in the anterior series in the upper jaw. All scales ctenoid.
  - X. Snout long and pointed. Hind teeth uniserial . . *Puntazzo.*
  - Y. Snout obtuse. Molars in 2–4 series . . . . *Diplodus.*

II. Scales on head extending well into the interorbital region. Enlarged molars, when present, always of outer series. Anterior teeth usually conical. Ground colour usually pink or red. Cross-bars rarely present, and then never dark or dusky.

- A. Preopercle flange naked. Scales fairly large, not more than 7 above the lateral line. At least one dorsal spine filamentous, longer than head . . . . *Argyrops.*
- B. Preopercle flange scaly. Scales moderate or small, more than 7 above the lateral line. None of the dorsal spines filamentous, sometimes elongate but not longer than head.
  - X. Scales moderate, less than 70 series. 12 or fewer

---

* The interorbital is a region generally taken as the "front of the head between the eyes." For the purpose of the present work it is more accurately defined as follows: The upper limit of the interorbital region is taken as that line at right angles to the dorsal profile farthest from the snout, which is tangential to any part of the upper margin of the orbit. The lower limit is an orbit breadth below.

dorsal spines. Maxilla at least partly exposed. Posterior nostril oval or slit-like.

a. Soft dorsal and anal naked, with low sheath. Outer anterior canines flaring outwards. Preorbital fairly shallow . . . . *Pterogymnus.*

b. Soft dorsal and anal scaly basally. Anterior conical teeth subvertical. Preorbital deep.

x. Molars biserial in upper jaw. Scales above lateral line much smaller than those below. Preopercle flange only partly scaly. Soft dorsal and anal black, ground colour dusky . . *Cymatoceps.*

y. Molars in more than two series in upper jaw. Scales above lateral line not much smaller than those below. Preopercle flange completely scaly. Soft dorsal and anal, and ground colour pink or red . . . *Chrysoblephus.*

Y. Scales small, more than 70 series. 13 dorsal spines. Maxilla completely concealed. Posterior nostril circular, small . . . . *Porcostoma.*

All previous workers have accepted South African species as falling in the typical genus *Sparus* Linn., of which the Mediterranean species *aurata* Linn. is the genotype. A detailed examination of graduated stadia of that species, and a comparison with equivalent stadia of our species supposedly congeneric, has shown that the South African species do not fall in *Sparus* Linn. That is to say, I cannot recognise them as congeneric with the species *aurata* Linn.; they are as clearly distinct generically from that species as from, *e.g.*, the species of *Diplodus* Raf. The typical genus *Sparus* has been included in the key to the Sparine genera in order to show the main relationships. Later it will be shown also in the Denticidae that the typically Indo-Pacific species are generically distinct from species confined to the Atlantic.

Genus *Acanthopagrus* Peters.

1855. Peters, Arch. Naturg., Pt. 1, p. 242. Type *vagus* Peters. No description. (Copied from Fowler, U.S. Nat. Mus. Bull. 100, 1933, vol. xii, p. 145. P. 158, *vagus*=*berda* Forsk.)

Body more or less ovate, moderately deep. Eye moderate. Posterior nostril elongate-oval. Mouth small, terminal; snout moderately sharp; profile concave or straight before eye. 4–6 acute or blunted subconical or incisiform teeth anteriorly in each jaw; no villiform teeth behind. Rounded molariform teeth in 3–5 series in each jaw; inner posterior slightly enlarged. Opercular spine exposed. 11 dorsal spines, strong;

fin originates over or in advance of the hind opercular margin; base of fin more than half body length. 2nd anal spine enlarged, stout. Pectoral longer than head. Soft dorsal and anal densely scaly at base. Scales large, cycloid to feebly ctenoid, not more than 50 series. Lateral line scales ctenoid, tubules slender. Cheeks scaly. Interorbital naked, porous. Muzzle and preopercle flange naked.

Olive or silvery, with or without cross-bars.

Genotype *berda* Forskäl.

Two species in South Africa, *berda* and *bifasciatus* Forsk., both of which extend into the Indo-Pacific. Probably the Indo-Pacific species, *australis* Gnthr., *latus* Houttuyn, and *cuvieri* Day, will also be found to fall in *Acanthopagrus.*

Acanthopagrus is a very distinct genus, at least as far as the South African Sparidae are concerned. From *Austrosparus* n.g., *Sparodon* n.g., and *Diplodus* Raf. it is distinguished by the larger scales, stronger fin spines, shape of snout, and markedly by the dense scaling on the soft dorsal and anal fins.

Acanthopagrus is clearly distinguished from the remaining Sparine genera by numerous features, *e.g.* naked interorbital, scaling, colour, etc., so that it is very surprising that Peters's genus has not before received recognition.

Key to the South African Species.

I. Dark cross-bars on head. Teeth oblique . . . . *bifasciatus.*
II. No bars on head. Teeth vertical . . . . *berda.*

Acanthopagrus berda Forskäl.

(Pl. XVIII, fig. 2, and text-fig. 3.)

1933. Fowler, *loc. cit.*, pp. 157–158 (References and Synonymy), and p. 146, *Sparus madagascariensis* Val. (?).

This species is so widely distributed and so well known that only the briefest description is necessary.

Body ovate, snout subconical. Depth 1·9–2·5, head 2·9–3·2 in length of body. Eye 3·5(juv.)–5, snout 2·6–3·3, interorbital 3·8–4·2 in length of head. Preorbital depth 1·1–2·0 in eye. Interorbital scarcely convex, porous, opercular spine prominent. Gill-rakers 9–11, slender. Maxilla extends below front third of eye, not concealed. 4–6 subconical teeth anteriorly in upper, 6–8 in lower jaw. 4 or 5 series of moderate molars in upper, 3–4 in lower jaw, inner posterior larger.

D XI, 11–12 : originates above or in advance of hind margin of operculum. Spines stout: 1st 5–6, 4th longest 2–2·2, last 3–3·5 in head, shorter

than soft rays, 4th ray 2–2·2 in head, edge of soft fin rounded. Base of dorsal 1·9 in body length.

A III, 8–9 : inserted below soft dorsal origin. 2nd spine curved and enlarged, 1·6–1·8 in head, 3rd $\frac{4}{5}$ of 2nd, first soft ray 1·9 in head, remainder shorter, edge of fin rounded. Pectoral longer than head, 2·5–2·7 in body; ventrals 3·5–3·7 in body, reach to vent. Caudal forked.

Scales moderate, those above lateral line cycloid, those below weakly

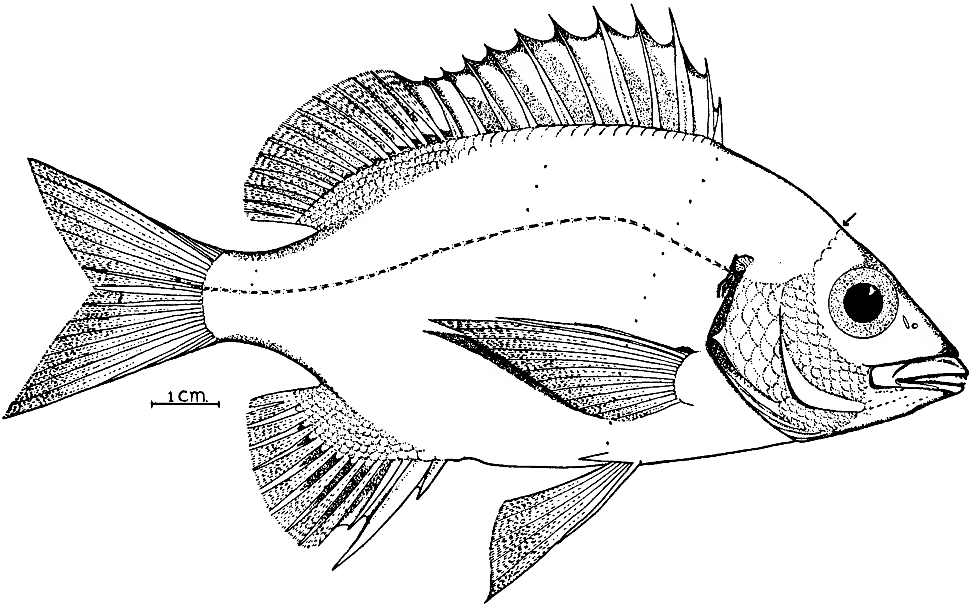


FIG. 3.—*Acanthopagrus berda* Forskäl.
The rows of dots show number and disposition of scales. The small arrow shows anterior limit of scaling on head.

ctenoid. Lateral line scales feebly ctenoid, tubule narrow (Pl. XVIII, fig. 2). l.l. 43–46, l.tr. $\frac{4\text{–}5}{9\text{–}11}$, 5–6 cheek scales. Scaling on head extends above hind pupil margin. Preopercle flange, muzzle, and interorbital naked. Soft dorsal and anal densely scaly basally.

Colour.—Silvery to olive, lighter below, sometimes lines along the scale rows, or scales with dusky edges. A dark blotch at lateral line origin, usually extending to membrane about opercular spine. Dorsal, caudal, and anal with some blackish markings; pectorals and ventrals light.

Locality.—Zwartkops estuary, Algoa Bay (rare), more plentiful eastwards to Natal and farther north, plentiful in estuaries, especially the young.

Distribution.—Apparently throughout the tropical Indo-Pacific.

Length.—Up to 400 mm. (S.A.): 750 mm. (India) (Day).

This widely distributed species appears to be somewhat polymorphous, with very numerous synonyms. It is not improbable that *berda* will eventually be divided into several subspecies or races.

Mr. Bell-Marley, to whom reference elsewhere is made, has expressed the opinion that two species are confused in *berda* in South Africa. I have not yet been able to satisfy myself, from available material, that they exist. Mr. Marley is, however, an acute observer and has had unique opportunities of handling a vast amount of material, so that the matter may be regarded as not yet settled.

Certainly the types of *robinsoni* G. and T. and of *aestuarius* G. and T. are clearly identical and referable to *berda* Forsk. Colour has little significance in species which live both in estuaries and in the sea. A fish which in surf or on sandy bottom in the sea is bright silvery, when taken in an estuary will generally be darker in colour; specimens from muddy areas high up the river may be even deep olive-dusky.

berda was placed in *Pagrus* Cuv. by Barnard (Ann. S.A. Mus., 1927, vol. xxi, p. 703) and in *Sparus* Linn. by Fowler (*loc. cit.*, 1933). *berda,* however, most emphatically does not belong to those genera, nor to any previously recognised in South Africa.

Acanthopagrus bifasciatus Forskäl.

(Pls. XVIII and XXIV and text-fig. 4.)

1933. Fowler, U.S. Nat. Mus. Bull. 100, vol. xii, p. 160 (copied) (References and Synonymy).

Body fairly deep, dorsal profile steep, prominent bulge at interorbital; snout pointed, concave before eyes. Depth 2, head 2·8 in body length. Eye 3·3, snout 2·6, interorbital 3·1, and postorbital 2·5 in length of head. Preorbital depth 2 in eye. Interorbital strongly convex, porous. Opercular spine prominent.

Mouth moderate, maxilla extends below centre of eye. In upper jaw 6 incisiform teeth with subconical bases, roots longitudinally produced. In the lower jaw 6 long incisiform teeth, both sets rather oblique. Molariform teeth in 4 series in upper, in 3 in lower jaw, posterior of middle series largest. Outer lateral series in upper jaw with more or less trenchant edge. Gill-rakers moderate, 11 on lower limb of anterior arch. Pyloric caeca moderate, 4–5.

D XI, 13 : originates in advance of hind margin of opercle. Spines stout, 3rd longest 2·2 in head, last 3·4 in head. Soft rays longer than last

spine. Mid rays longest, edge of fin rounded. Base of dorsal 1·7 in body length.

A III, 10 : inserted below middle of soft dorsal. 2nd spine strong, 1·9 in head, 1·3 times 3rd. Soft rays longest anteriorly, edge of fin gently convex. Pectorals 1·2 times head, reach well beyond anal origin. Ventrals 1·2 in head, reach beyond vent but not to anal. Caudal forked.

Scales large, some on nape and shoulder cycloid, the remainder ctenoid,

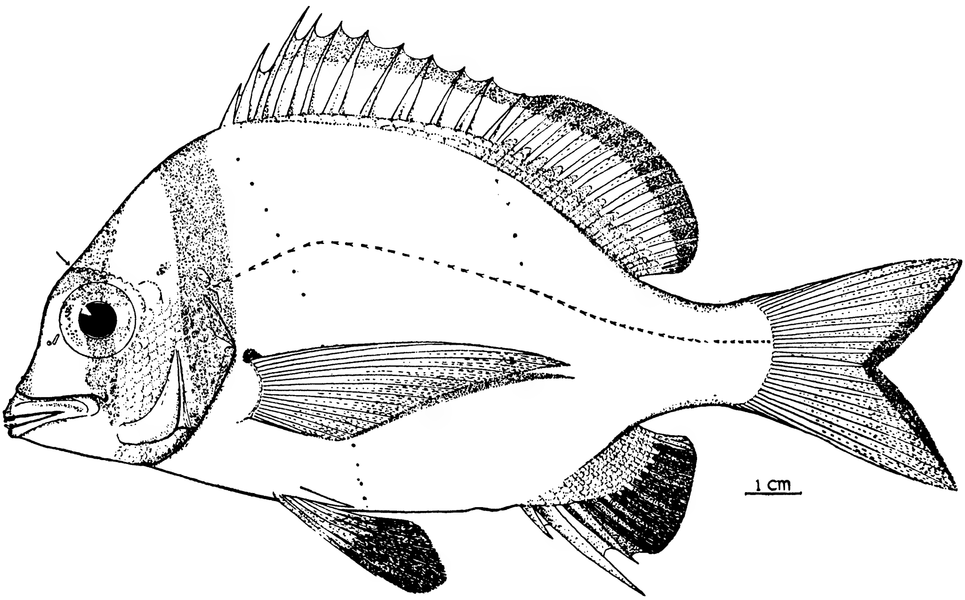


FIG. 4.—*Acanthopagrus bifasciatus* Forskäl.
The rows of dots show number and disposition of scales. The small arrow shows anterior margin of scaling on head.

more strongly towards ventral area. Radiating striae fairly numerous, all scales with gently rounded margins (Pl. XXIV, figs. 6 and 7). Lateral line scales feebly ctenoid, tubules narrow without posterior series of pores; hind margin of scales deeply notched (Pl. XVIII, fig. 6). l.l. 49, l.tr. $\frac{5}{12}$, 7–8 cheek scales, 28–30 predorsal, end above slightly behind front eye margin. Preopercle flange and muzzle naked. Interorbital naked, porous. Soft dorsal and anal densely scaly basally.

Colour.—Silvery olive, lighter below. A dark bar, little narrower than eye, from nape over opercle. A narrower and fainter bar from occiput through eye, ending at angle of mouth. Snout and interorbital dusky. Dorsal light dusky with broad dark marginal band. Anal dark except

last ray. Ventrals dark on distal $\frac{3}{4}$. Caudal light dusky with dark hind margin. Faint lines along the scale rows (probably only in preserved specimens).

Described from a specimen, 170 mm. in length, from Natal.

Distribution.—South Africa, Red Sea, India. Very rare in South Africa, and never south of Natal.

No South African specimens have apparently ever been described, certainly not in recent years. Fowler (Proc. Ac. Nat. Sci. Phil., 1934, vol. lxxxvi, p. 470) described a fish from Zululand as *bifasciatus* Forsk. which cannot be that species, but is more likely *Austrosparus sarba* Forsk. (*q.v.*). Fowler has probably not seen a specimen of *bifasciatus* from South Africa.

Barnard (Ann. S.A. Mus., 1927, vol. xxi, p. 703) gave a description of *bifasciatus* which was probably compiled. He placed that species in *Pagrus* Cuv., although his description stated the anterior teeth of *bifasciatus* to be incisors.

A. bifasciatus is a somewhat anomalous species and difficult to place. In some respects, *e.g.* oblique incisors, it is reminiscent of *Diplodus*, but numerous other features rule that out. It agrees best with *Acanthopagrus*, in which it is at present placed. It is not unlikely that *bifasciatus* will eventually be separated as a possibly monotypic genus.

Genus *Austrosparus* n.g.

1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 684 (*Sparus*).

Body compressed, fairly deep. Head and nape moderately broad; snout blunt. Eye fairly large. Posterior nostril oval or slit-like. Mouth moderate. In upper jaw 4–6, in lower 4–8 subequal heavy incisiform teeth, edges entire, or tricuspid in juvenile stadia (*auriventris* Peters), never conical. No villiform teeth. Rounded molariform teeth in 3 or more series in each jaw, the inner posterior always enlarged, usually very much so. Maxillary and mandibulary bones very heavy. Opercular spine concealed. 11 dorsal spines, fairly slender. 2nd anal spine not enlarged. Soft dorsal and anal naked, with very low sheath. Dorsal base usually longer than half body length. Dorsal originates behind hind margin of operculum. Pectoral longer than head.

Scales moderate, more than 50 but less than 65 series. Lateral line scales and those above cycloid, only those on lower and hinder parts of body feebly ctenoid. Lateral line tubes broad, with posterior double diverging series of pores. Preopercle flange naked, or with a few scales (*auriventris*). Interorbital naked, porous.

Skull typical, frontals moderately broad. Colour silvery to silvery olive, with cross-bars in young, persist to adult in one species.

Genotype *globiceps* Cuvier. Other South African species *sarba* Forsk. and *auriventris* Peters.

The species *globiceps* and *sarba* have been placed in the genus *Sparus* Linn. by all recent workers. At the same time it has been obvious that most arrangements of our Sparid fishes have been based upon neither intensive research nor adequate material, and far too little attention has been paid to the nature of the dentition and of the scales. Further, the differences between groups of species accepted as generically distinct have been quite irrational. There are, for example, far more important differences of generic rank between the species *sarba* Forsk. and *berda* Forsk. than between *sarba* Forsk. and *sargus* Linn., and yet the majority of workers have held the former two congeneric, but retained *sargus* as distinct from *sarba* by generic rank.

The genotype of *Sparus* Linn. (i.e. *aurata* Linn.) differs from the South African species in certain important features, notably in the dentition, the anterior teeth being fang-like or caniniform from the earliest stadia, while those of our species are always incisiform, either with edges entire, or tricuspid in juveniles. Further, in *aurata* all the scales are cycloid and considerably smaller than in any of our species, while in *aurata* the preorbital is deeper and the eye smaller. With regard to dentition, it may be noted that diagnoses of *Sparus* Linn. generally state the front teeth are conical or caniniform. Fowler (*loc. cit.*, 1933, p. 64), in his key to Sparid genera, defined the group in which *Sparus* Linn. was included as having "front teeth conic, not compressed or incisor-like." This he confirmed some pages later in his diagnosis of the genus *Sparus* Linn. (*loc. cit.*, p. 145), where he stated "jaws with 4–6 conic canines anteriorly." Then in his key to the species of that genus (p. 147) he separated four species as the subgenus *Sparus*, in having "front teeth in each jaw incisors." Still further in those four species was included *australis* Gnthr., in the description of which Fowler stated (p. 152) "6 front conic canines in each jaw." In the same key Fowler defined *Chrysoblephus* Swainson as a subgenus distinct from *Sparus* in having the front teeth conic canines. Yet, on p. 161, *bifasciatus* Forsk., which he placed in *Chrysoblephus*, was stated to have "incisors 4–6 in each jaw."

Such inaccuracy and inconsistency is both regrettable and misleading. In any case the subgenus *Sparus* based upon the presence of incisiform teeth is invalid without special emendation, since the type of that genus has caniniform or fang-like anterior teeth.

In Spariform fishes the dentition is surely of considerable importance, and it is here treated as such.

In view of the evidence adduced, it would appear reasonable to accept *Sparus* Linn. as confined to the Mediterranean and Atlantic. Many of our species are related to *Sparus*, but completely separated geographically as they are, have diverged sufficiently to warrant generic distinction. Certainly they merit generic distinction from *Sparus* Linn. as much as do the species of *Diplodus* Raf.

Generally *sarba* Forsk., *globiceps* Cuv., and *durbanensis* Cast. have been grouped together. In the present work *durbanensis* is separated from the other two and forms the type of a new genus. With regard to *sarba* Forsk. it has been discovered that two distinct species had been confused under that name in South Africa. Mr. Bell Marley, Principal Fisheries Officer of Natal, has for many years held that view, but could find no worker to substantiate it. It has now been found that a species which is very abundant from the Cape all along the south coast of South Africa to Natal, hitherto stated to be *sarba* Forsk., is not that species, but has been identified with *auriventris* Peters, a hitherto doubtful name placed in the genus *Diplodus* Raf. There are therefore three species which fall in *Austrosparus*.

None of the species of *Austrosparus* grow to a large size. They feed chiefly upon mollusca, the dentition being extremely powerful; in large specimens the molars form an almost continuous pavement across the roof and the floor of the mouth.

The distribution of the species is interesting: *globiceps* is most abundant about the Cape, becoming scarcer eastwards; *auriventris* is most abundant along the coast from about Mossel Bay to Durban; while *sarba* does not extend farther south and west than about Port St. Johns, being unknown west of East London.

Key to the species of Austrosparus.

I. (*Austrosparus*):
 Preopercle flange naked. Incisors even in juveniles with entire edge.
  A. Adult with dark cross-bars. Pectoral 1·1 times head . . *globiceps.*
  B. No cross-bars in adult. Pectoral 1·3–1·4 times head . . . *sarba.*

II. (*Rhabdosargus* Fowler):
 Preopercle flange with a few scales.
  Anterior incisors tricuspid in juveniles . . . . . . *auriventris.*

Austrosparus globiceps Cuvier.

(Pls. XVIII and XXIII and text-fig. 5.)

1927. Barnard, Ann. S.A. Mus., 1927, vol. xxi, p. 685, fig. 23*a* (head).
1933. Fowler, U.S. Nat. Mus. Bull. 100, vol. xii, p. 148 (copied) (References).

Body more or less ovate. Dorsal profile of snout more or less undulate with marked interorbital prominence. Depth 2·4–2·6, length of head

2·9–3·2 in length of body. Eye 3·0–4·5, snout 2·4–3, interorbital 2·8–3·2 in length of head. Preorbital depth 1·0–1·7 (juv.) in eye. Opercular spine concealed. Gill-rakers short, 7–9 on lower part of anterior arch. Maxilla extends to below anterior part of eye. In upper jaw 4–6, in lower 4–8 incisiform teeth; in juveniles these teeth are acute, but become more chisel-edged with age. 4–5 series of molars in upper and 3–4 in lower jaw, fewer in young fishes, inner hinder molars much enlarged.

D XI, 11–12: inserted just behind hind margin of operculum. Spines slender, 3rd–5th longest, 1·8–2·2 in head.

A III, 10–11: inserted below anterior dorsal rays. Pectorals 1·1 times

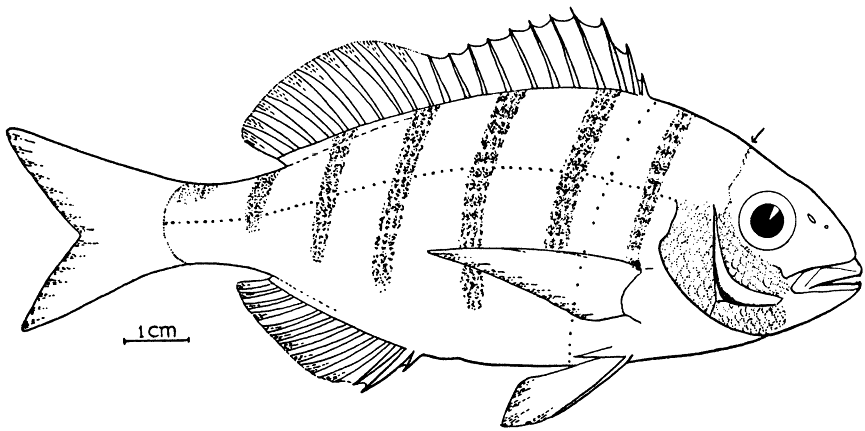


FIG. 5.—*Austrosparus globiceps* C. & V. (Juvenile.)
The rows of dots on body and head show number and disposition of scale rows. The small arrow shows anterior limit of scaling on head.

head, reach above anal spines. Ventrals 1·6 in head, reach vent. Caudal forked, upper lobe larger.

Scales moderate; lateral line scales and above cycloid. Radiating striae numerous. Scales on hinder and lower side feebly ctenoid (Pl. VI, figs. 6 and 7). Lateral line tubes broad with 2 very widely diverging series of 4–5 pores to hind margin (Pl. XVIII, fig. 5). l.l. 57–61, l.tr. $\frac{5\text{–}6}{14\text{–}16}$, 6 or 7 series across cheek. Predorsal scales end above hind third of eye. Preopercle flange and muzzle naked. Interorbital quite naked, porous.

Colour.—Silvery or dusky silvery above, lighter below. 6–7 narrow vertical dark cross-bars, more or less equally spaced, first over shoulder, last over peduncle. Axil of pectoral and opercular margin dark. Interorbital dusky. Dorsal and anal dusky, usually dark blotches between the rays. Other fins also dusky, mid-caudal rays sometimes dark at apices. Iris golden or bronzy.

Locality.—Coast of South-West Africa to the Cape and round to Natal.

Endemic in South Africa; attains a length of 500 mm. Occasionally occurs in very large shoals and often taken in nets. Economically important, the flesh being esteemed.

Small specimens are much like equivalent-sized *auriventris* Peters, which are similarly banded. The young of *globiceps* may always be distinguished by the naked preopercle flange and by the acute incisors, those of equivalent *auriventris* being tricuspid.

Austrosparus sarba Forskäl.

(Pls. XVIII and XXIII and text-fig. 6.)

1917. Gilchrist and Thompson, Ann. Durb. Mus., vol. i, pt. 4, p. 361 (*natalensis*).
1927. Barnard, *loc. cit.*, p. 687 (part).
1933. Fowler, *loc. cit.*, p. 149 (part).
1934. Fowler, Proc. Ac. Nat. Sci. Phil., vol. lxxxvi, p. 470 (*bifasciatus*).

Body ovate, dorsal profile steep, nape rather narrow. Depth 1·9–2·1, length of head 3·3–3·5 in length of body. Eye 3·3–4·3, snout 2–2·3, interorbital 3·3–4 in head. Preorbital depth 1·2–1·5 in eye, lower margin almost straight; interorbital not very prominent, porous. Gill-rakers 7–8, short. Maxilla extends to below pupil. In upper jaw 4–6, in lower usually 6, often with 2 median smaller, incisiform teeth; in young or half-grown fishes the incisors are rather pointed, become broader and flatter with age. In upper jaw 4–5 series of molariform teeth, 3–4 series in lower, the inner hinder enlarged, markedly so in large fishes, almost forming a pavement across the mouth.

D XI, 12–13: originates over or behind hind margin of operculum. Spines fairly stout, 4th usually longest, about 2 in head.

A III, 11: originates below anterior dorsal rays. Pectorals 1·3–1·4 times head, reach to above middle of anal, 2·3–2·4 in body length. Ventrals 1·2 in head, reach to or beyond vent. Caudal moderately forked.

Scales moderate, radiating striae numerous, margins broadly rounded, more so than equivalent scales of *globiceps*. Lateral line scales and those above cycloid. Scales on lower hinder parts ctenoid (Pl. XXIII, figs. 3 and 8). Lateral line tubes broad with 2 diverging series of pores behind (Pl. XVIII, fig. 3). l.l. 56–59, l.tr. $\frac{7\text{–}8}{12\text{–}14}$, 4–5 cheek scales. Predorsal scaling extends above centre of eye. Preopercle flange and muzzle naked. Interorbital entirely naked, porous.

Colour.—Dull silvery olive to silvery above, lighter below. An indistinct narrow stripe along each scale row, arched above lateral line, more or less straight below. Stripes clearer on preserved specimens. A faint axillary spot.

Locality.—Natal south coast, Durban, and north to Zululand, also in estuaries. Extends to the Indo-Pacific.

Grows to a length of 600 mm. or more.

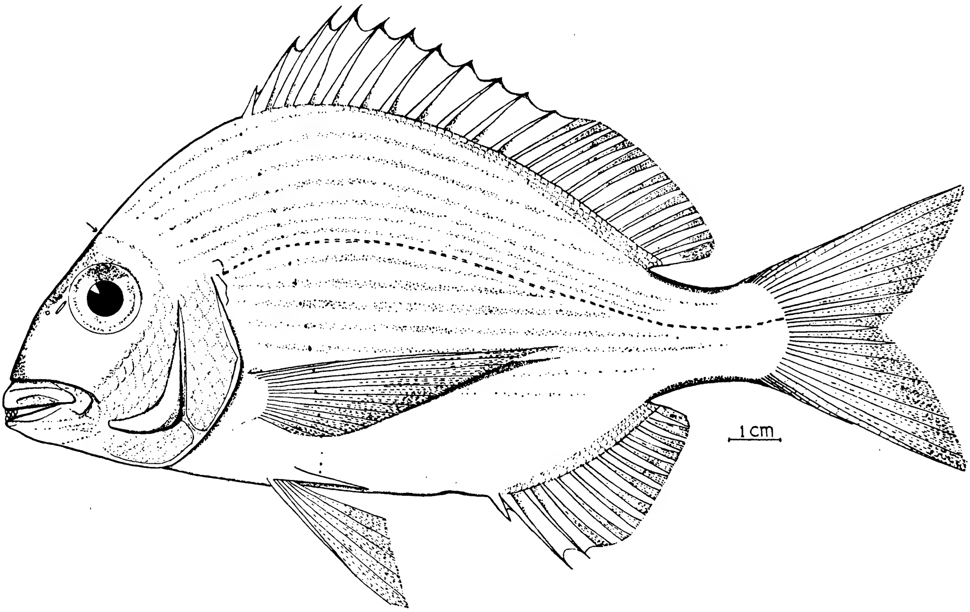


FIG. 6.—*Austrosparus sarba* Forskäl.
The rows of dots indicate number and disposition of scale rows. The small arrow shows anterior margin of scaling on head.

I have not seen a specimen of *sarba* Forsk. from the type locality (Red Sea), but there is little doubt that the Natal form is that species. *Sarba* does not appear to extend much south of Durban, certainly not west of East London. Specimens do not ever have the longitudinal golden band characteristic of the species *auriventris* Peters, which occurs also in Natal waters with *sarba*. The latter may easily be distinguished even in preserved specimens by the longer pectoral and naked preopercle flange; juveniles of the two species are readily distinguished by the nature of the incisors, those of *auriventris* being tricuspid.

Austrosparus auriventris Peters.

(Pls. XVIII and XXIII and text-figs. 1, 7, and 8.)

1835. Ruppell, Neue Wirbel, p. 110, pl. 28, fig. 1 (*sarba*).
1855. Peters, Arch. Naturg., p. 243 (*Diplodus auriventris*, locality Madagascar). (Copied from Fowler, *loc. cit.* below.)
1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 687 (*sarba* Forsk., part).
1933. Fowler, *loc. cit.*, p. 149 (*sarba* Forsk., part), p. 178 (*Diplodus auriventris* Peters).

Body elongate ovate. Dorsal profile sloping from nape, concave above

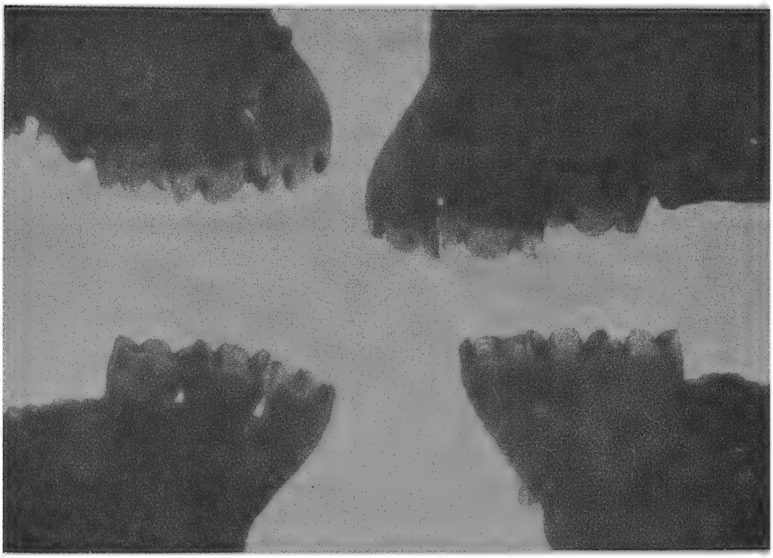


FIG. 7.—Anterior teeth of *Austrosparus auriventris* Peters.
From specimen 35 mm. length. ×25.

eyes, sharply convex before eye, interorbital prominent above steeply sloping snout.

Depth 2·2–2·4, length of head 3·3–3·5 in length of body. Eye 3·0–4·0, snout 2–2·2, interorbital 3·5–4·1 in length of head. Gill-rakers 7–8, short. Maxilla extends to below anterior third of eye. In upper jaw 6, in lower 6–8 incisiform teeth anteriorly. In juveniles these teeth are tricuspid (text-fig. 7), the cusps diminishing with growth, but traces still visible in specimens 130 mm. in length. Up to the ordinary adult stadia the incisors form a continuous cutting edge, but in very large specimens they change to a blunted molariform shape. In upper 4–5, in lower jaw 3–4 series of molars, inner hinder enlarged, enlargement increasing with age.

D XI, 12–13: originates behind hind margin of operculum. Spines moderate, 4th longest 2·5–2·6 in head.

A III, 10–11: inserted below anterior dorsal rays. Pectorals 1·15–1·2 times head, do not reach beyond spinous anal, 2·7–2·8 in body length. Ventrals 1·4–1·5 in head, scarcely reach vent. Caudal moderately forked.

Scales moderate, those above lateral line vertically elongated. Radiating striae numerous. Lateral line scales and those above cycloid, scales on lower and hinder parts of body ctenoid (Pl. XXIII, figs. 1 and 2).

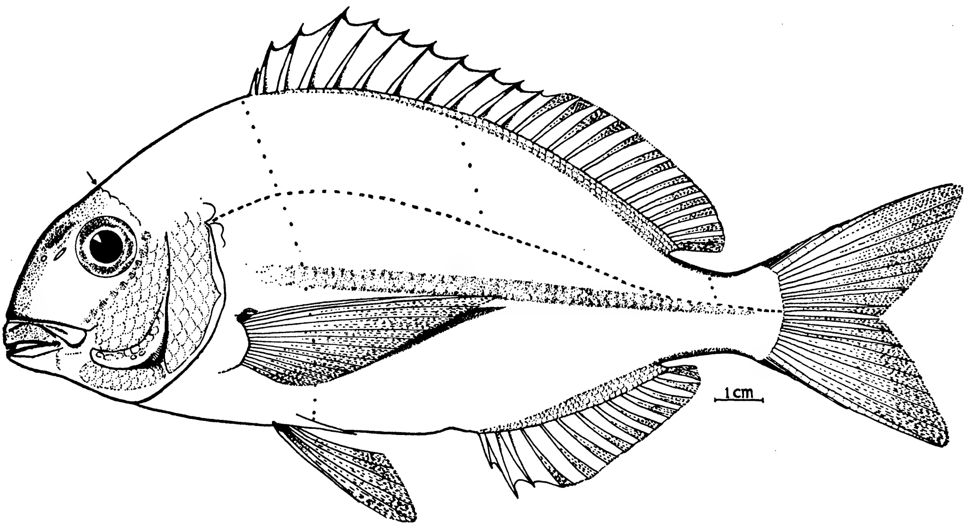


FIG. 8.—*Austrosparus auriventris* Peters.
The rows of dots indicate number and disposition of scale rows. The small arrow shows anterior margin of scaling on head.

Lateral line tubes stout, with 2 narrowly diverging series of pores behind (Pl. XVIII, fig. 1). l.l. 55–57, l.tr. $\frac{6\text{–}7}{12\text{–}13}$, 4–5 cheek scales. Predorsal scales extend to above front pupil edge. Interorbital naked, porous. Muzzle naked. Preopercle flange with variably few cycloid scales, mostly near ridge, present in all stadia, usually obscured in young fishes.

Colour.—Bright silvery; in estuaries usually varies to olive when water is dark, lighter below. When alive a straight narrow golden stripe along side, from near pectoral axil to caudal base just below lateral line; also some golden reflections from hind parts of scales in shoulder region. These golden markings fade rapidly on preservation. A dark axillary spot. Juveniles generally have 6–7 narrow dark cross-bars, which fade with age, though even adults show them as a nocturnal colour-phase. Dorsal olive to dusky. Nape dusky. When alive, anal and ventrals golden, especially

in juveniles. Iris golden. Preserved specimens develop faint streaks along the scale rows.

Locality.—From Breede River, Port Beaufort, along the coast eastwards, in all estuaries and in the sea, to Natal; Zululand; Madagascar.

Probably extends to Red Sea and Indian region. Largest recorded specimen 500 mm. total length (South Africa).

It is curious that this species has not previously been recognised in South Africa. When alive or fresh, even in the largest specimens, the golden lateral stripe is brilliant and obvious. With this is associated the scales on the preopercle flange, and the tricuspid teeth of juveniles, all distinctive features enabling the species to be distinguished from *sarba* and *globiceps* at all stadia and in all degrees of preservation.

There can be no question of the validity of *auriventris.* I have not seen Peters's original description, nor any (as *auriventris*) except that compiled by Fowler (*loc. cit.*, 1933, p. 178). But that description could hardly fit more exactly, and I have no hesitation in applying Peters's name to this species so very abundant in our South African estuaries.

When the three species of this genus are compared, it is found that *globiceps* is most abundant at the Cape, but becomes progressively scarcer eastwards. The young enter estuaries, but never in great numbers. *A. auriventris* is very abundant from Mossel Bay eastwards, especially in all tidal rivers, and occurs with *sarba* in Natal waters. *A. sarba* does not extend far south; in fact, among thousands of specimens of *Austrosparus* examined, taken between East London and Mossel Bay, I have never seen one typical *sarba.* The differences between *sarba* and *auriventris* can be neither sexual nor environmental, since both sexes of *auriventris* occur south of Natal, and both species occur together in Natal and farther north.

Although hitherto placed in *Diplodus* Raf., *auriventris* is unquestionably more closely related to *sarba* and *globiceps.*

It may be indicated that juveniles of *auriventris* often have dark cross-bars, so as to resemble equivalent stadia of *globiceps*; with growth these cross-bars disappear. However, *auriventris,* even when adult, will often show dark cross-bars as a nocturnal colour phase. Generally the dark markings fade after death, but in occasional specimens they persist. *Sargus holubi* Steindachner is probably merely *auriventris* with cross-bars (see Barnard, *loc. cit.*, 1927, p. 688).

Genus *Sparodon* n.g.

Body elongate oval. Head large and broad, interorbital wide. Snout blunt and heavy. Eye small. In each jaw 4 front incisors, the middle pair very much enlarged and curved, upper overlapping lower. Molar

teeth large, in 3 or more series, inner enlarged. Upper lip very thick at snout tip. 11 dorsal spines, slender. Dorsal base less than half body length. 2nd anal spine not enlarged. Soft dorsal naked with well-developed sheath, soft anal scaly basally. Pectoral shorter than head. Scales moderate, more than 50 but less than 65 series. Lateral line scales and those above cycloid, those on lower surface ctenoid. Lateral line tubes fairly broad, with 2 series of pores behind. Preopercle flange naked. Interorbital naked, porous.

Skull typical, frontals very broad.

Colour silvery, no cross-bars at any stage.

Genotype *durbanensis* Castlenau (monotypic).

S. durbanensis has hitherto been accepted as congeneric with *globiceps* and *sarba,* to which it is closely related, and as falling in the genus *Sparus* Linn. *S. durbanensis* shows features which appear to justify its separation from *globiceps* by full generic rank. The enlarged curved median incisors, the included lower jaw, very broad head, more elongate body, and other characters are distinctive. Also the habits, etc., of the species (*vide infra*) set it apart from the related forms mentioned above.

S. durbanensis is endemic, and so far as I can determine there are no species from other parts which might be congeneric. The genus *Sparodon* is thus endemic and monotypic.

Sparodon durbanensis Castlenau.

(Pls. XVIII and XXIII and text-fig. 9.)

1927. Barnard, *loc. cit.*, p. 687, pl. xxviii, fig. 4 (*Sparus d.*).

Head broad and heavy. Dorsal profile gently sloping from nape, concave above eyes, with slight interorbital prominence. Depth 2·6–2·9, length of head 3·2–3·4 in length of body. Eye 4(juv.)–6·5, interorbital 2·0–2·5, and snout 2·2–3 in length of head. Preorbital depth less than eye in juveniles (< 180 mm.), up to 1·5 times eye in large adults. Lower margin of preorbital undulate, curves down over much-exposed maxilla end. 8–9 short gill-rakers on lower limb of the anterior arch. Opercular spine visible. Mouth fairly large, maxilla extends to below middle of eye, lower jaw shorter than upper. In each jaw 4 narrow incisors, the median pair curved and much enlarged, those in upper jaw exsert, visible externally overlapping the lower jaw. Large molars in 4–5 series in upper and in 3–4 in lower jaw, inner hinder much enlarged. In large specimens the teeth form an almost continuous pavement across the jaw.

D XI, 11 : inserted well behind hind margin of opercle. Spines slender, 4th longest, 2·4–2·6 in head, remainder decrease to the last, soft rays

higher, 3rd as long as 4th spine. Edge of fin gently convex. Base of dorsal less than half body length.

A III, 10 : inserted below anterior dorsal rays, 3rd spine longer than 2nd. Pectorals 1·2–1·3 in head, do not reach above anal origin. Ventrals 1·6–1·7 in head, do not reach vent. Caudal moderately forked.

Scales moderate, hind margin irregularly undulate, radiating striae fairly numerous (Pl. XXIII, figs. 4 and 5). Lateral line scales and those above cycloid, ventral scales feebly ctenoid. Lateral line scales almost as long as wide, tubule broad with 2 diverging series of pores behind (Pl. XVIII, fig. 4).

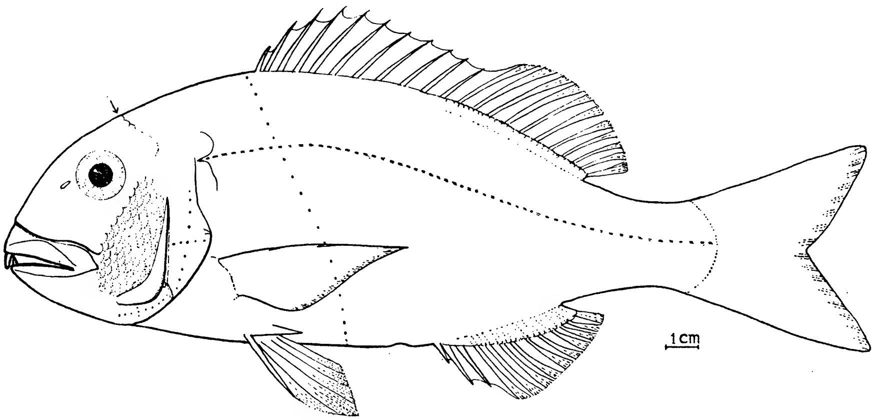


FIG. 9.—*Sparodon durbanensis* Cast. (Juvenile.)
The rows of dots indicate scale rows. The small arrow shows anterior limit of scaling on head.

l.l. 58-61, l.tr. $\frac{6\text{–}7}{14\text{–}15}$, 7 cheek scales. Predorsal scales extend forward above hinder third of orbit. Interorbital naked and porous. Muzzle and preopercle flange naked. Soft dorsal with well-defined scaly sheath. Soft anal scaly basally.

Colour.—Silvery, or silvery blue above, lighter below, dusky on preservation. Margins of dorsal, anterior part of anal, and distal half of ventrals dusky or dark. Very young specimens show longitudinal stripes (which fade with growth), while the ventrals, anal, sometimes also the caudal, are bright orange.

Locality.—From the Cape to Natal, not in estuaries, generally near rocks.

Sparodon durbanensis may be distinguished from all other South African Sparid fishes, in all but the youngest stadia, by the central pair of large curved incisors, those in the upper jaw being especially prominent, overlapping those in the lower, and visible even when the mouth is closed. In

very young fishes the anterior incisors are subequal, the abnormal development of the two median pairs commencing in fishes of about 70 mm. length. The dentition of *durbanensis* is heavier than in any other South African Sparid fish. In large adults the molars become very large, the inner posterior enlarged molars often being over an inch in length and half an inch in width.

Small specimens of this species are at times (October–January) fairly plentiful in rock-pools along the south-eastern coast. The body is deeper than in the adult, and fine longitudinal bands are usually present. The soft fins of the young are orange.

Durbanensis usually frequents rather shallow water and is frequently hooked at high tide in the inter-tidal zone. Large specimens are much prized by anglers, as they provide excellent sport and require skilful handling to land.

Genus *Puntazzo* Bleeker.

1933. Fowler, U.S. Nat. Mus. Bull. 100, vol. xii, p. 179.
1936. Fowler, Bull. Am. Mus. Nat. Hist., vol. lxx, pt. 2, p. 844.

Body fairly deep. Jaws and muzzle attentuate, almost beak-like; 8 truncate oblique incisors in a single series in each jaw, and behind those a single series of small compressed teeth.

This is typically a Mediterranean genus. A single species, *Puntazzo puntazzo* Cetti, has been recorded from South Africa, but only two specimens have been taken in over sixty years, so that it can scarcely be regarded as typically South African.

I have not been able to examine a specimen.

Genus *Diplodus* Rafinesque.

1933. Fowler, *loc. cit.*, p. 175.
1936. Fowler, *loc. cit.*, p. 836.

Body compressed, deep. Snout fairly blunt, steep. Eye moderate. Posterior nostril oval or slit-like. Mouth small, maxilla almost or completely concealed. Anterior teeth incisiform, oblique, truncated, 8–12 in each jaw; small molariform teeth in 2 or 3 series in each jaw. Dorsal spines fairly slender. Soft dorsal and anal naked with low sheath.

Scales moderate to small, ctenoid. Lateral line scales with pores posteriorly, in some cases as openings of bifurcating main tubes. Preopercle flange and interorbital naked. Colour silvery to yellow with or without dark cross-bars.

This genus has generally been accepted by systematists and is undoubtedly valid. It is more closely related to *Austrosparus* than to *Sparus*;

Austrosparus is in some respects intermediate between *Diplodus* and *Sparus*. It is exceedingly difficult to understand why systematists have accepted *Diplodus* but rejected equally well-defined genera such as *Chrysoblephus* Swainson, usually hitherto regarded as a synonym of *Sparus* Linn.

Two species of *Diplodus* occur in South Africa, *sargus* Linn. and *trifasciatus* Raf. It is probable that at some time they will be separated generically, for there are numerous differences of more than ordinary specific rank. Also the species of *Diplodus* from other parts would appear to be divisible into two groups on those same features. Nevertheless, it would not be wise to separate our two species generically without examining material from other parts, unfortunately not available here.

Key to the South African Species.

I. Lips thin, not continued across. Incisors large, 8 in upper jaw; molars triserial. No cross-bars in adult . . . . *sargus.*

II. Lips thick, continuous across symphysis. Incisors small, 12 in upper jaw; molars biserial. Cross-bars in all stadia . . . . . *trifasciatus.*

Diplodus sargus Linn.

(Pls. XIX and XXIV and text-fig. 10.)

1933. Fowler, U.S. Nat. Mus. Bull. 100, vol. xii, p. 175.

It appears to be accepted generally that the South African form is identical with the typical form of the Northern Atlantic and Mediterranean. At one time *sargus* from South Africa was separated as the variety *capensis* A. Smith. Barnard (1927, *loc. cit.*, p. 690) was not satisfied with that distinction, and Fowler (*loc. cit.* 1933, above) decided that the South African form was identical with the typical *sargus*, but regarded *noct* Val. as distinct. Subsequently Fowler (Bull. Am. Mus. Nat. Hist., 1936, vol. lxx, pt. 2, p. 840) has revived *capensis* as a species distinct from *sargus* Linn., stating that the latter has cross-bars in juvenile stadia, while *capensis* has not. If by *capensis* is meant the species occurring in South Africa, then the distinction is not valid, since the juveniles from South Africa show cross-bars, and even in half-grown specimens they are sometimes visible, especially as a nocturnal colour phase.

The species does not require more than a very brief description. Depth 1·9–2·3. Incisors large, 8 in each jaw; molars usually triserial above and below, 4 series above in larger fishes. Gill-rakers 10, moderate.

D XII, 14–15; A III, 13–14.

Scales ctenoid; lateral line tubes short and stout with several pores behind (Pl. II, fig. 1, and Pl. VII, figs. 1 and 2). l.l. 62–72, l.tr. $\frac{8\text{–}9}{18\text{–}19}$.

Juveniles are silvery with several narrow, dark cross-bars and a dark spot or saddle on peduncle. With age the colour darkens; large adults may be so dark that the peduncular blotch is scarcely discernible, while cross-bars are rarely observed beyond the half-grown stages save as a nocturnal colour phase. Length up to 400 mm. Known from all parts of the South African region.

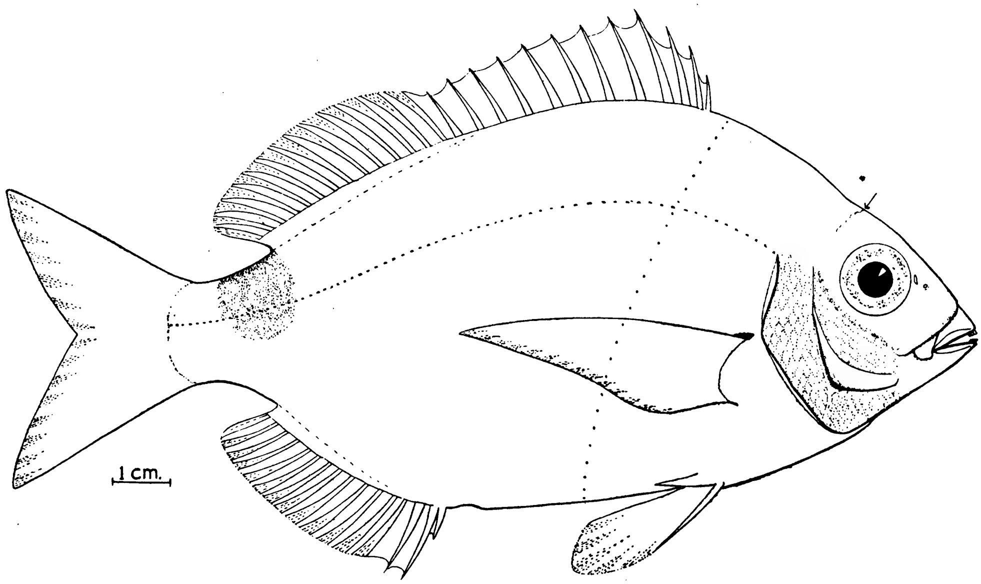


FIG. 10.—*Diplodus sargus* Linn.
The rows of dots represent number and disposition of scale rows. The small arrow shows anterior margin of scaling on head.

Diplodus trifasciatus Rafinesque.

(Pls. XIX and XXIV and text-fig. 11.)

1933. Fowler, *loc. cit.*, p. 177.
1936. Fowler, Bull. Am. Mus. Nat. Hist., vol. lxx, pt. 2, p. 837, fig. 362.

This well-known species scarcely requires redescription.

It is generally held to be identical with the form from the North Atlantic, and that view is accepted here, although the figures that I have seen do not resemble our fish very closely.

The chief differences between *trifasciatus* and *sargus* are: the former has thick lips continuous across the symphyses, the incisors are 12 in number and rather small, molars are in 2 series and small, the preorbital conceals the maxilla completely, while the lateral line tubes bifurcate and the branches open externally each by a large pore (Pl. II, fig. 2). Ordinary

scales are shown in Pl. XXIV, figs. 4 and 5. The colour, when alive, is usually yellowish, and the broad dark cross-bars are present in all stadia.

This species occurs throughout the South African region and attains a length of 500 mm.

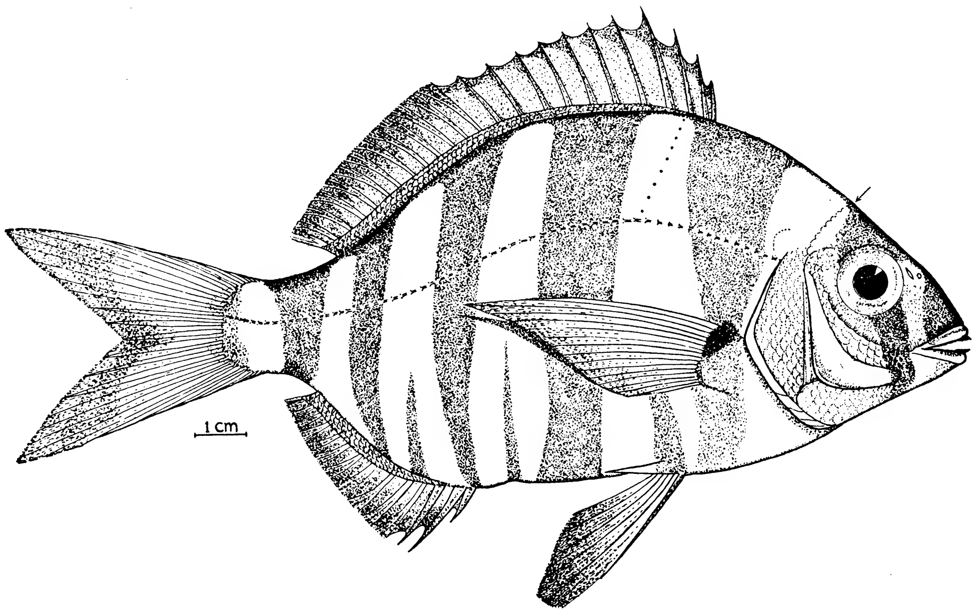


FIG. 11.—*Diplodus trifasciatus* Raf.
The rows of dots show number and disposition of scale rows. The small arrow shows anterior margin of scaling on head.

Genus *Argyrops* Swainson.

1933. Fowler, U.S. Nat. Mus. Bull. 100, vol. xii, p. 143.

Body fairly deep, ovate. Eye moderate. Snout blunt, steep. Mouth small or moderate. Anterior teeth conical, molars in 2 or 3 series in each jaw, no villiform teeth. Dorsal spines 11 or 12, first 2 very short, 3rd elongate, sometimes also 4th to 6th filamentous. Soft dorsal and anal scaly basally.

Scales ctenoid, fairly large on body, not more than 55 series, 7 or 8 above. Preopercle flange naked. Interorbital scaly.

Genotype *spinifer* Forsk.

This genus has not generally been accepted at full rank; and has been regarded as monotypic. *filamentosus* Valenciennes is now also included.

The genus is well worthy of maintenance on the combination of large scales, very short first 2 dorsal spines, filamentous 3rd dorsal spine,

and naked preopercle flange. Fowler (1933, *loc. cit.*, p. 168) proposed *Dulosparus* as a new subgenus of *Sparus* Linn. for *filamentosus* Val. without ever having seen a specimen. Later (Proc. Ac. Nat. Sci. Phil., 1935, vol. lxxxvii, p. 390), when he examined a specimen, he placed it in *Sparus* without mentioning his proposed subgenus. The two species occur in the Indian region, the type extending to the Pacific.

Key to the Species.

I. Four dorsal spines filamentous. Gill-rakers lanceolate . . . *spinifer.*
II. Only the 3rd dorsal spine filamentous. Gill-rakers tubercle-like . . *filamentosus.*

Argyrops spinifer Forsk.

(Pls. XX and XXV.)

1933. Fowler, U.S. Nat. Mus. Bull. 100, vol. xii, p. 143 (References and Synonymy).

This species is so well known and has so often been described that detailed redescription is not necessary. It can hardly be confused with any other species.

Dorsal profile very steep, snout blunt. Depth 1·7–1·9. Eye 3–3·4 in head. 4–6 sharp conical teeth in the front of each jaw. Preorbital deep. Gill-rakers 9–10 on the lower limb of the anterior arch.

D XI–XII, 10–11 : first 2 spines short. 3rd–6th filamentous, in juveniles longer than body, in large adults shorter but still very elongate.

A III, 8 : soft dorsal and anal scaly basally.

Scales ctenoid, rounded; lateral line scales with 2 large pores behind tubes (Pl. XX, fig. 3; Pl. XXV, figs. 1 and 2). l.l. 49–53, l.tr. $\frac{7\text{–}8}{16\text{–}18}$, 5 rows on cheek. Interorbital scaly, scales extend to above hind nostril. Preopercle flange naked.

Reddish or light brown, young with faint cross-bars.

Length.—Up to 600 mm.

Locality.—Natal; extends throughout the Indo-Pacific.

Uncommon in South Africa, but always easily recognisable by the 4 much-elongated dorsal spines, in very young fishes longer than the body. I have examined the type of *Pagrus ciliaris* von Bonde (S.A. Fish. Mar. Bio. Surv. Spec. Rep., No. 1, p. 19, pt. 5, 1923) and it appears to be merely the juvenile form of *spinifer* (confirming the opinion of Barnard, 1927, *loc. cit.*, p. 696).

Argyrops filamentosus Valenciennes.

1933. Fowler, U.S. Nat. Mus. Bull. 100, vol. xii, p. 168 (References).
1935. Fowler, Proc. Ac. Nat. Sci. Phil., vol. lxxxvii, p. 390, fig. 24.

The following description is compiled:—

Depth 2, length of head 3·2 in length of body. Eye 3–3·7, snout 2–2·5, interorbital 2·8 in length of head. Preorbital deeper than eye (in adult). 4 conical teeth in front, and 3 rows of molars in each jaw. 9 gill-rakers on lower limb of anterior arch, short, tubercle-like.

D XII, 10 : first 2 spines minute, 3rd elongate, filamentous, 2·7–3 in length of body, 4th spine fairly long but not filamentous, remainder shorter.

A III, 8: ventral 1·3 in, pectoral 1–1·2 times head.

l.l. 51–54, l.tr. $\frac{6\text{–}7}{14\text{–}15}$, 6 rows across cheek. Preopercle flange naked. Interorbital completely scaly, scaling extends forward well in advance of anterior margin of eye.

Colour reddish, even to fins. Largest recorded size 334 mm.

A rare species, only one specimen taken in South African waters, in North Zululand. Other specimens have been known from the Indian Ocean.

It is possible that this species merits generic distinction from all other Sparid fishes. I have not been able to examine a specimen, but from the description *filamentosus* would appear to be more closely related generically to *spinifer* Forsk. than to any other species.

Genus *Pterogymnus* n.g.

Body ovate, fairly compressed. Eye large, preorbital fairly shallow. Mouth moderate, in front of upper jaw 4, in lower 6 caniniform teeth, the outer pair in each jaw flaring outwards. Molars small, upper biserial. Lips strongly villose. Dentaries cavernous, light. Maxillary bones moderately heavy. Maxilla with acute projecting infero-anterior process, which forms a notch at junction on lower anterior margin of preorbital. Opercular spine concealed. Hind nostril oval. 12 dorsal spines, moderate. 2nd and 3rd anal spines about equal. Soft dorsal and anal naked, with very low sheath. Pectoral about equal to head. Scales moderate, ctenoid; lateral line scales with 2 or 3 large pores behind tubule. Preopercle flange and interorbital completely scaly. Colour reddish.

Genotype *laniarius* Cuvier.

Generally the genotype has been regarded as congeneric with species here placed in *Chrysoblephus* Swainson. Fowler (1933, *loc. cit.*, p. 153) placed it in *Sparus* Linn. Actually *laniarius* merits full generic distinction

from all other Sparid fishes by the combination of outwardly flaring canines, weak biserial molars, naked median fins, scaly preopercle flange and interorbital, and shallow preorbital. Further, the species generally lives in deeper water than most other Sparid fishes.

Pterogymnus laniarius Cuv.

(Pls. XIX and XXV and text-fig. 12.)

1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 694, fig. 24 (head).
1933. Fowler, U.S. Nat. Mus. Bull. 100, vol. xii, p. 153.

Body compressed, ovate. Dorsal profile sloping to snout.

Depth 2·3–2·5, length of head 2·8–3·1 in length of body. Eye 3·2–4·0, snout 2·3, interorbital 3·3–3·8, and postorbital 2·6 in length of head.

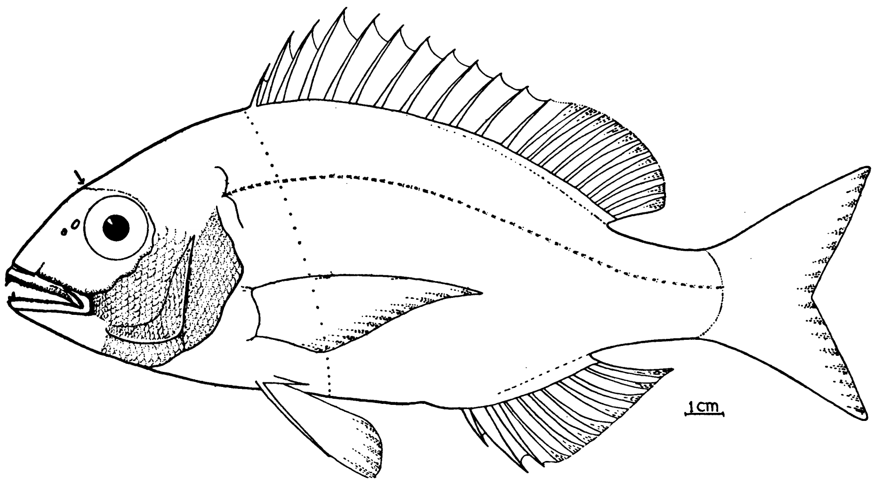


FIG. 12.—*Pterogymnus laniarius* Cuvier.
The rows of dots indicate number and disposition of scale rows. The small arrow shows anterior margin of scaling on head.

Preorbital depth less than eye, almost equal to eye in large adults, lower margin straight, a deep notch between anterior lower angle and projecting inferior maxillary process. Hind margin of preorbital undulate. Posterior nostril oval.

Gill-rakers 12–13, moderate.

Mouth fairly large, maxilla extends below anterior margin of pupil. In upper 4, in lower jaw 6 canines, the outer pair in each jaw strongest and flaring outwards. Molars in 2 series in upper jaw, outer more or less acute in all but largest specimens. Villiform teeth behind symphyses. Lips strongly villose.

D XII, 10 : 4th and 5th spines longest, 2·3–2·4 in head, thereafter graduated shorter, soft rays higher than last spine. A III, 8 : 2nd spine stouter but no longer than 3rd. Pectoral almost as long as head, ventrals 1·6–1·7 in head. Scales moderate, ctenoid (Pl. XXV, figs. 4 and 5). Lateral line scales notched behind, tubule short and stout with several large pores behind (Pl. XIX, fig. 3). l.l. 56–59, l.tr. $\frac{8}{17\text{–}18}$, 9 scales across cheek. Interorbital and preopercle flange scaly; scales on head extend above posterior nostril. Soft dorsal and anal naked, but with low scaly sheath.

Colour.—Light pink-rosy, sometimes with faint longitudinal stripes, white below. Fins pink.

Locality.—From the Cape Peninsula to beyond East London, usually in fairly deep water, down to 60 fathoms. Confined to South Africa.

Length.—Up to 400 mm.

This species has generally been grouped with *gibbiceps* Cuvier and related species, but it certainly merits full generic distinction for reasons given above. It may be noted that it is an exception among Sparine fishes in not coming close inshore in shallow water. Its capture by rock anglers occurs very rarely, if ever. I have never heard of its being taken other than in deep water by line or trawl. *P. laniarius* is of considerable commercial significance.

Barnard's figure (*loc. cit.*, 1927) of the head of this species shows the eye to be less than the preorbital depth, which is erroneous.

This species may easily be identified even when the body has decomposed, or from a skeleton, by the acute maxillary process, the outwardly flaring canines, and the cavernous mandibles. It is probably almost exclusively carnivorous, and is to some extent a connecting link between the Sparidae and the Denticidae; in habits and appearance it resembles the latter, but the skeleton leaves no doubt that it falls in the Sparidae.

Genus *Cymatoceps* n.g.

Body oblong oval, compressed. Eye moderate to small, preorbital deep. Mouth moderate. 4 canines in upper, 4–6 in lower jaw, no villiform teeth. Molars biserial in upper jaw, outer row much the larger, inner small. In juveniles outer molars acute. No villiform teeth. Maxillary bones heavy. Hind nostril oval. 12 dorsal spines, short. 2nd anal spine longer than 3rd. Soft dorsal and anal densely scaly basally. Pectoral shorter than head.

Scales ctenoid, moderate to small, those above the lateral line very much smaller than those below. Lateral line tubes moderate, with a few pores behind. Preopercle flange with a few median series of scales but naked

mostly along ridge and margin. Cheek scales very small. Interorbital scaly, scales on head extend forward well in advance of eye. Colour dusky to black.

Genotype *nasutus* Castlenau, monotypic and endemic. *Cymatoceps* is distinguished from all other Sparid genera by the combination of biserial molars, caniniform anterior teeth, heavy scaling on dorsal and anal fins, partly scaly preopercle flange, scales above lateral line much smaller than those below, and the dark colour of body and fins. It is most closely allied with *Chrysoblephus* Swainson, but the ground colour, only part scaling of the preopercle flange, and the great difference in size between the scales above and below the lateral line, as well as the habits of the type, render generic distinction desirable.

Cymatoceps nasutus Castlenau.

(Pls. XX and XXV and text-fig. 13.)

1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 695.
1935. Smith, Rec. Alb. Mus., vol. iv, p. 204, pl. xxii, B.

This characteristic endemic species does not require more than the briefest description. Large adults are immediately recognisable by the large fleshy process, or "Nose," developed on the snout.

At all stadia the scaly soft dorsal and anal are dusky black, as is also generally the dominant ground colour.

Juveniles are not as easily recognised since they differ from the adult in certain features: there is no "Nose," the colour is often dusky brown with sometimes lighter nebulous patches on the sides. Also in juveniles the lateral molars are acute, and only in the adult do they acquire the characteristic smooth rounded crowns.

This species is generally found among rocks, even large specimens often come into quite shallow water.

Depth 2·3–2·5. Eye 4–6 in length of head. Preorbital depth greater than eye. Maxilla extends below anterior part of eye. Canines slender in juveniles, become obtuse in old specimens. Molars in 2 series, outer larger, more or less conical in juveniles.

D XII, 10: spines fairly stout, 3rd–5th subequal, longest, 3 in head. Soft fin anteriorly somewhat elevated. A III, 8: 2nd spine usually longer and stronger. Pectoral 1·1–1·3, ventrals 1·7 in head. Caudal emarginate.

Scales ctenoid, those above the lateral line very much smaller than those below (Pl. XXV, figs. 3 and 8). Lateral line tubes moderate, with one or two pores behind (Pl. XX, fig. 5). l.l. 61–65, l.tr. $\frac{11\text{–}12}{21\text{–}24}$, 16 cheek scales.

Preopercle limb scaly only down median portion. Interorbital scaly; scaling extends forward above anterior nostril. Soft dorsal and anal densely scaly basally.

Colour.—Dusky to black. Soft dorsal and anal black, and ventrals also in half-grown fishes.

Locality.—Cape Peninsula to Natal. Specimens over 100 lbs. in weight not uncommon.

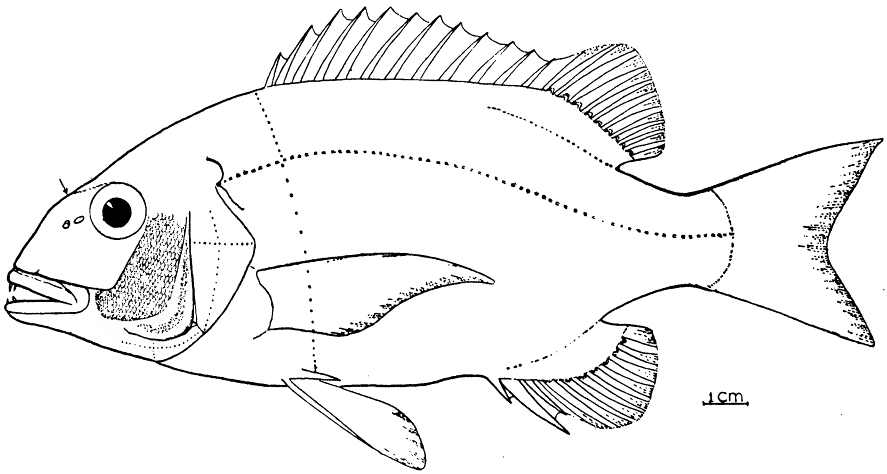


FIG. 13.—*Cymatoceps nasutus* Cast. (Juv.)
The rows of dots represent number and disposition of scale rows. The small arrow indicates the anterior margin of scaling on head.

nasutus is more or less omnivorous and is the largest of all the Sparid fishes in South Africa, where it is esteemed by anglers as a sporting fish.

It does not enter estuaries save under exceptional circumstances.

Genus *Chrysoblephus* Swainson.

Body fairly deep, moderately to greatly compressed. Eye moderate, preorbital fairly deep. Mouth moderate, 4–6 canines in each jaw, usually with villiform teeth behind. Molars in 3 or more series in each jaw, outer row larger than inner, usually acute in juveniles. Hind nostril oval or slit-like.

Twelve dorsal spines, moderate or strong, sometimes elongated but not longer than head. 2nd anal spine not much longer than the 3rd. Soft dorsal and anal densely scaly basally. Pectoral usually longer than head.

Scales ctenoid, more or less rounded, moderate to small, 50–65 series,

those above the lateral line not much smaller than those below. Lateral line tubes stout and short, oblique, with several pores behind tubes. Preopercle flange completely scaly. Cheek scales moderate. Interorbital scaly, scaling on head well in advance of front eye margin. Colour pinkish or reddish, sometimes with faint darker red cross-bars.

Genotype *gibbiceps* Cuvier.

This genus has not hitherto been accepted at its full rank. Barnard (Ann. S.A. Mus., 1927, vol. xxi, p. 692) did not even accept the designation of *gibbiceps* as genotype as valid, since he regarded the description of the dentition (by Swainson) as erroneous. Actually that definition is somewhat ambiguous, but may easily be applied to *gibbiceps*. Most other workers have accepted that species as the genotype of *Chrysoblephus*, but have recognised the latter as worthy of only subgeneric rank at best. Fowler, *e.g.* (*loc. cit.*, 1933, p. 147), has placed it as a subgenus of *Sparus* Linn.

In the course of the present work it has been obvious that the species here placed in *Chrysoblephus* definitely merit generic distinction from all other Sparid fishes. Whether or no an examination of the precise terms of Swainson's diagnosis will ultimately establish *Chrysoblephus* I cannot determine, not having access to the original text. It has been decided to accept *Chrysoblephus* as of valid definition.

The dominant red colour, the molars in 3 or more series, the anterior canines, the scaly dorsal and anal fins, scaly interorbital and preopercle flange, and general habits all combine to establish the validity of the genus.

Hitherto there have been accepted only four species of *Chrysoblephus* (as here defined), viz. *gibbiceps* Cuv., *anglicus* G. & T., *laticeps* Cuv., and *cristiceps* Cuv. Gilchrist and Thompson (Ann. S.A. Mus., 1908–11, vol. vi, p. 173) described a Natal species as *puniceus* G. & T., but most later workers of repute have accepted Barnard's opinion (*loc. cit.*, 1927, p. 700) that *puniceus* was a synonym of *cristiceps*. A re-examination of the type of *puniceus*, and complete specimens of that species, has shown it to be valid and clearly distinct from *cristiceps*.

Also Fowler (Proc. Ac. Nat. Sci. Phil., 1925, vol. lxxvii, p. 234, fig. 3) described a Natal fish as *Sparus lophus* n. sp., which was not accepted, and has since been regarded as a synonym of *gibbiceps* Cuv. A specimen recently to hand from Natal shows that *lophus* may be accepted as valid.

There are thus six species in the genus, and all frequent moderately to fairly deep water on rocky ground. They are typically marine and do not enter estuaries in normal circumstances. Some are of considerable economic significance, and are mostly taken on lines from boats in 5–40 fathoms. They are caught by shore anglers only where the water deepens rapidly.

Key to the Species.

I. Profile of snout sloping. Forehead very broad (not gibbous) with a dark (blue) transverse band . . . . *laticeps.*

II. Profile of snout moderately steep. Nape sharp, never gibbous. No cross-bars.

- A. l.l. 59–61. 9–10 gill-rakers . . . . *cristiceps.*
- B. l.l. 49–52. 14–15 gill-rakers . . . . *puniceus.*

III. Profile of snout very steep. Nape gibbous. Usually faint cross-bars.

- A. l.l. 53–58. Scales on cheek with a forward patch below eye.
  - X. Scales on cheek extending well in advance of above hind margin of maxilla. 3rd dorsal spine not longer than 1·5 in head . . . . *gibbiceps.*
  - Y. Scales on cheek not extending in advance of above hind margin of maxilla. 3rd dorsal spine almost to full length of head . . . . *lophus.*
- B. l.l. 63–67. Scales on cheek obliquely back from corner of mouth without forward patch below eye . . . . *anglicus.*

Chrysoblephus laticeps Cuv.

(Pls. XIX and XXVI.)

1927. Barnard, *loc. cit.*, p. 701 (References and Synonymy).

This well-known and plentiful species does not require detailed redescription. It may easily be distinguished from the other species of the genus by the sloping profile, by the shallower body, and by the coloration. The interorbital and nape are broad and convex.

Depth 2·3–2·5. Eye 3·3–4·5 in head, greater than (juv.) to slightly less than (ad.) preorbital depth. Gill-rakers 10.

D XII, 10 (abnormally XI, 11); A III, 7–9.

Scales ctenoid, radiating striae few (Pl. XXVI, figs. 1 and 2). Lateral line tubes very short and stout, with two large pores behind (Pl. XIX, fig. 5). l.l. 58–61, l.tr. $\frac{9\text{–}10}{19\text{–}21}$, 12–14 rows on cheek. Scaling on head extends above nostrils. Soft dorsal and anal densely scaly at base.

Orange or reddish, shading paler below, head usually brilliant orange. A blue bar across the interorbital (darkens on preservation). Usually a more or less triangular light patch on the side of the body, fades out with preservation, larger in juveniles. Pectoral axil darkish. Fins rosy, often with bluish tinge in ventrals. A blue colour variety is known from the Cape, but the light patch on the side is present.

Extends from the Cape through Natal to Zanzibar and Mauritius.

This characteristic species is well known all along the South African coast and is generally taken where the water is not too shallow. It is generally known as "Roman" or "Red Roman," and at times is caught in

large numbers, the average being $1\frac{1}{2}$–2 lbs. in weight, though specimens 18 inches in length have been taken. The flesh is palatable, though in certain localities it is rather rank.

Chrysoblephus cristiceps Cuv.

(Pls. XX and XXVI and text-fig. 14.)

1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 700.

Dorsal profile elevated, steeply sloping and undulate, large concavity from above eye to snout tip. Nape fairly sharp.

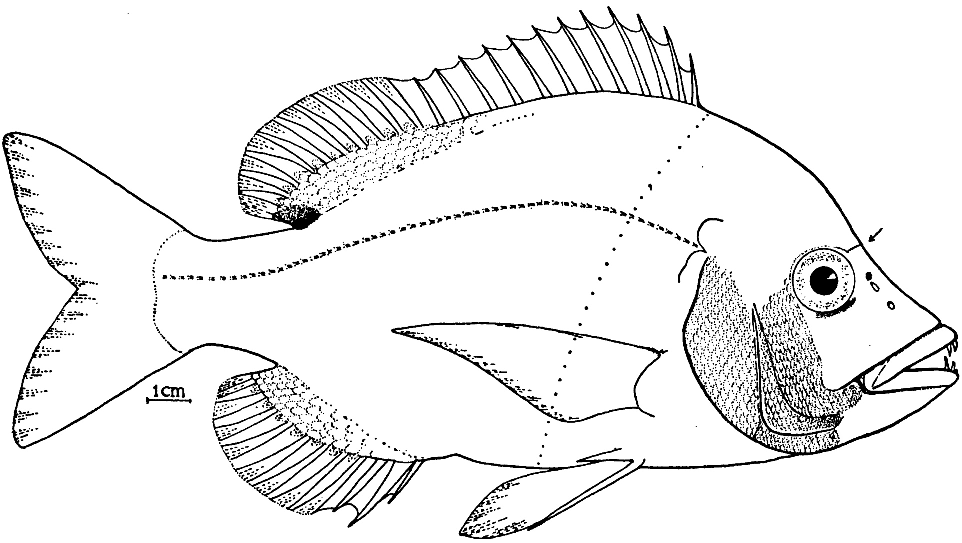


FIG. 14.—*Chrysoblephus cristiceps* Cuv.
The lines of dots represent number and disposition of scale rows. The small arrow indicates anterior margin of scaling on head.

Depth 2·2–2·3, length of head 2·8–3·0 in length of body. Eye 3·6–6·0, snout 2·3–2·5, interorbital 3·5–3·7, and postorbital 2·5 in length of head.

Preorbital depth 1·1–1·3 times eye; lower margin of preorbital almost straight. Gill-rakers 9–10 on lower limb of anterior arch. Maxilla extends below hind nostril or farther, not to eye margin; extremity well exposed. Anterior canines large. Lateral molars acute in juveniles, more rounded in adults, much larger than inner series.

D XII, 10: spines fairly stout, 4th and 5th longest, 2·3–2·5 in head, edge of soft fin rather convex. A III, 8: soft fin similar to dorsal. Pectoral 1·0–1·2 in head. Ventrals 1·5 in head.

Scales ctenoid (Pl. XXVI, figs. 3 and 8). Lateral line tubes moderate

with two pores behind (Pl. XX, fig. 2). l.l. 59–61, l.tr. $\frac{9\text{–}10}{19\text{–}20}$, 11 cheek scales. Interorbital scaly, scaling on head extends to slightly in advance of eye. Preopercle flange completely scaly.

Colour.—Reddish, variegated with golden and blue reflections from the scales. Faint blue bar below orbit; hind margin of opercle and scapular scaling bluish. A dark spot in pectoral axil, and a black spot with dusky to blue shading above at base of last dorsal rays. The play of colour over the body of this species immediately preceding and just after death is beautiful almost beyond description; waves of colour, blue, green, bronze, orange, and red, alone and intermingled, sweep over the body and continually surge up and die away.

Length.—Up to 630 mm.

Locality.—Cape Peninsula, chiefly Agulhas Bank, and eastwards to Natal. Most plentiful along the south coast of South Africa.

A very characteristic species, of considerable economic significance, occurring in large numbers from False Bay to East London; the flesh is generally highly esteemed. *cristiceps* is a rare capture from the shore, save where the land dips sharply to deep water. Usually the "Dageraad" is taken on banks in 10–50 fathoms.

As mentioned by Barnard (*loc. cit.*, 1927) the body shape changes somewhat with age; the nape becomes elevated and the body more or less triangular in large adults.

Chrysoblephus puniceus Gilchrist and Thompson.

(Text-fig. 15.)

1908. Gilchrist and Thompson, Ann. S.A. Mus., vol. vi, p. 173.
1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 700 (*cristiceps* part).

Dorsal profile of snout very steep, almost straight from nape. Nape very sharp, with a ridge before the dorsal fin.

Depth 2–2·1, length of head 3·3–3·4 in length of body. Eye 3·6 (juv.)–4·0, snout 2·4–2·6, interorbital 3–3·6, and postorbital 2·7 in length of head.

Preorbital depth slightly less than (juv.) to slightly more than eye diameter. 14–15 gill-rakers on lower limb of anterior arch. Maxilla extends to below anterior margin of eye, extremity almost covered. Anterior canines moderate. Lateral molars somewhat acute even in larger specimens.

D XII, 10: spines slender, 3rd and 4th longest, subequal, 2·0–2·1 in head, edge of soft fin gently convex. A III, 8 : soft fin similar to dorsal. Pectoral 1·2–1·3 times head. Ventrals 1·2–1·3 in head.

Scales ctenoid; lateral line tubes moderate, with two pores behind. l.l. 49–52, l.tr. $\frac{10}{18}$, 8–9 cheek scales. Interorbital scaly, scaling on head extends to above anterior nostril. Preopercle flange completely scaly.

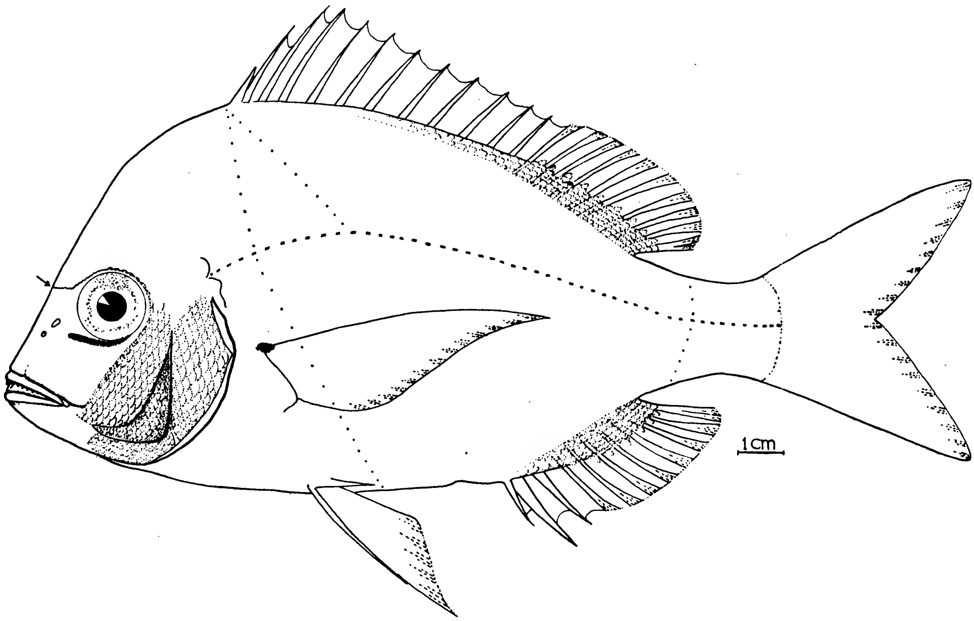


FIG. 15.—*Chrysoblephus puniceus* G. & T.
The lines of dots represent number and disposition of scale rows. The small arrow indicates anterior margin of scaling on head.

Colour.—Reddish with blue reflections. A blue bar below eye. Fins rosy.

Length.—Up to 350 mm.

Locality.—Natal and Zululand coasts.

This species has for some years been accepted as conspecific with *cristiceps* Cuv. Actually it is clearly distinct, as the following table shows:—

	cristiceps.	*puniceus.*
Depth in length . .	2·2	2·0
Head in length . .	2·8–3·0	3·3–3·4
l.l.	59–61	49–52
Pectoral with head . .	1·0–1·2 in.	1·2 times
Gill-rakers . . .	9–10	14–15

Also there are other differences: e.g. *cristiceps* always has the dark spot at the base of the last dorsal ray, and only a faint bar below the eye, while the snout profile is concave before the eyes; *puniceus* has no dark dorsal spot, but the bar below the eye is heavy and the snout profile is almost straight.

It is indeed peculiar to find two fishes so closely related as *cristiceps* and *puniceus* so sharply divided in their distribution in a relatively restricted area. *puniceus* is certainly rare, if known at all, west of the Great Kei mouth, while *cristiceps*, so abundant west of East London, is a very rare capture in Natal waters.

It may be remarked that Mr. Bell Marley, to whom reference has earlier been made, has always maintained that *puniceus* was a valid species, but has not hitherto been able to have his opinion confirmed.

Chrysoblephus gibbiceps Cuv.

(Pls. XIX and XXVI.)

1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 698, fig. 25 *b* (head) (part).

Snout profile very steep, almost vertical, concave between snout tip and nostrils, a bulge at interorbital which is generally pitted or spongy, increasingly so with age. Snout fairly sharp, somewhat pointed. The nape, probably only in males, becomes gibbous and prominent, a large "forehead" protruding. Depth 2·15–2·4, length of head 2·9–3·2 in length of body. Eye 3·5–4·5, interorbital 3·1–3·3, snout 2·1–2·3, and postorbital 2·1 in length of head. Eye 1·0(juv.)–1·6(ad.) in preorbital depth. Mouth moderate, maxilla extends to below anterior third of eye or to below pupil. Canines moderate, subvertical. Outer molars largest, 4–5 series in each jaw. 11–12 gill rakers on lower limb of anterior arch.

D XII, 10 (rarely XI, 11): spines graduated, 1st 5·4–6·8, 2nd 3·0–3·5, 3rd 2·0–2·5, 4th 2·0–2·4 in head, remainder graduated shorter. Soft fin evenly convex, longest ray 2·8–2·9 in head. Base of dorsal 1·4–1·5 in body length.

A III, 8: inserted below origin of soft dorsal. 2nd spine longest 3·3–3·5 in head. Edge of soft fin evenly convex, longest ray 2·8–2·9 in head.

Pectorals 1·0–1·1 in head, reach to above origin of soft anal. Ventrals 1·6–1·7 in head, do not reach beyond vent.

Scales ctenoid (Pl. XXVI figs. 4 and 5). Lateral line tubes large, with two pores behind (Pl. XIX, fig. 6). l.l. 52–55, l.tr. $\frac{9\text{–}10}{18\text{–}19}$. Cheek scaling with a forward extension of smaller scales along the middle of the preorbital below the eye, the anterior margin of the scaling extending well forward of above the hind margin of the maxilla. 10–11 scales from the

preopercle ridge to preorbital margin, 24–25 series in all on cheek. Scales on head extend above anterior nostril: from the front the scaling reaches down to the level of the centre of the eye. Preopercle flange scaly.

Colour.—Patchy white to pink, often with scattered darkish spots. Light reddish above with 6 or 7 darker red cross-bars, which fade on preservation.

Length.—Up to 500 mm.

Locality.—False Bay to Algoa Bay, usually in deeper water, up to 50 fathoms; Agulhas Bank.

A very characteristic species, plentiful in the False Bay area, progressively much scarcer eastwards. Large specimens with the strongly gibbous nape have a rather singular appearance.

Fowler (U.S. Nat. Mus. Bull. 100, 1933, vol. xii, p. 165) accepts records of *gibbiceps* from Australia.

Chrysoblephus lophus Fowler.

1925. Fowler, Proc. Ac. Nat. Sci. Phil., vol. lxxvii, p. 234, fig. 3.

Snout profile very steep, subvertical, concave between snout tip and nostrils, a prominent bulge at interorbital which is wrinkled and spongy. Snout rather sharp, almost rodent-like, protrudes.

Depth 2·17, length of head 3·0 in length of body. Eye 3·9, snout 2·2, interorbital 2·9, and postorbital part of head 2·2 in length of head. Eye 1·1 in preorbital depth (1·0 in *gibbiceps* of equivalent size). Mouth moderate, maxilla extends below front margin of eye. Canines moderate, somewhat oblique, outer molars far the largest. Inner molars in bands, irregularly spaced, about 5 series in each jaw. 10 gill-rakers on the lower limb of the anterior arch.

D XII, 10: 3rd–5th spines abruptly differentiated forming a crest. 1st spine 7·8, 2nd 4·3, 3rd 1·04, 4th 1·3, 5th 1·7 in head; remainder graduated shorter. Soft fin evenly convex, longest ray 2·4 in head. Base of dorsal 1·6 in body length.

A III, 9: inserted below origin of soft dorsal. 2nd spine longest, 3·1 in head. Longest soft ray 2·7 in head. Pectorals 1·2 times head, 2·5 in length of body, reach beyond soft anal origin. Ventrals 1·5 in head, reach beyond vent.

Scales ctenoid, lateral line tubes stout with several pores behind, very like those of *gibbiceps* Cuv. l.l. 58, l.tr. $\frac{9}{18}$. Cheek scaling with a forward extension of smaller scales along the preorbital, the anterior margin of the scaling does not extend forward beyond above the hind margin of the maxilla: 8 or 9 scales from preopercle ridge to hind margin of preorbital, 15 series in all on cheek. Scales on head extend above anterior nostril:

from the front the scaling reaches down to the level of just below the upper margin of the eye. Preopercle flange scaly.

Colour (preserved).—Light brown, probably reddish in life. Oblique rows of small indistinct dusky spots above the lateral line anteriorly, sloping down to cover most of the caudal region. A dark bar across the interorbital, possibly blue in life.

Length.—260 mm.

Locality.—Natal.

Fowler's description of the type of *lophus* is rather inadequate in so far as the establishment of the validity of the species is concerned, and Barnard's refusal to accept *lophus* in the absence of the type or of a typical specimen was fully justified. My experience that Natal forms have so often proved distinct from those of the Cape has led me to seek a specimen corresponding with that described by Fowler. I have been fortunate in receiving one from Dr. Lawrence, Director of the Natal Museum, which agrees in most particulars with Fowler's description. Comparison with specimens of *gibbiceps* has shown that *lophus* is most probably a valid species, although most extraordinarily closely related to *gibbiceps*. *lophus* is distinguished chiefly by the nature of the scaling on the cheek (the forward patch does not extend nearly as far towards the snout as in *gibbiceps*), as well as by the greater length of the fins, notably the very elongate 3rd and 4th dorsal spines. The spines of *gibbiceps* are sometimes elongate, but there is never the abrupt differentiation of the anterior spines from the others as in *lophus*. Also *lophus* differs from *gibbiceps* in having a dark transverse interorbital bar, a deeper preorbital, a wider interorbital, more scales, and an extra anal ray. The anterior canines of *lophus* appear to be more oblique than those of *gibbiceps*.

Apparently only two specimens of *lophus* have ever been taken—the type (unfortunately in America, and so inaccessible) and the one described above. The case of *gibbiceps* and *lophus* resembles that of *cristiceps* and *puniceus* in this genus.

Chrysoblephus anglicus Gilchrist and Thompson.

(Pls. XIX and XXIV and text-fig. 16.)

1908. Gilchrist and Thompson, Ann. S.A. Mus., vol. vi, p. 172.
1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 700, fig. 25 *a* (head).

Dorsal profile of snout almost vertical, not or scarcely concave. Nape slopes gently to interorbital. Depth 2·3–2·5, length of head 3·2 in length of body. Eye 3·5–4·7 in head, 1·1(juv.)–2 in depth of preorbital. Snout very blunt. Canines moderate, outer molars largest, 4–5 inner series. (No gills in any specimens examined.)

D XII, 10: 3rd and 4th spines longest, 1·5–1·7 in head. A III, 8. Pectoral 1·1–1·2 times, ventral 1·4 in head. Scales ctenoid (Pl. XXIV, figs. 3 and 8). Lateral line tubes very oblique, with two diverging series of pores behind (Pl. XIX, fig. 4). l.l. 65–68, l.tr. $\frac{10\text{–}11}{23\text{–}25}$, 11–12 scales on cheek, no forward patch below eye. Interorbital scaly, scaling on head extends above posterior nostril. Preopercle flange scaly.

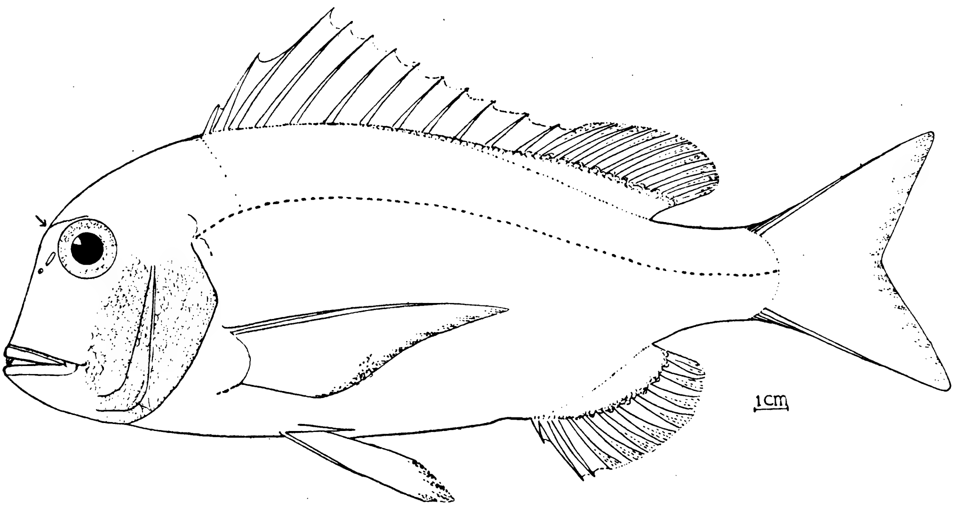


FIG. 16.—*Chrysoblephus anglicus* Gilchrist and Thompson.
The rows of dots indicate the number and disposition of the scale rows. The small arrow shows the anterior margin of scaling on head.

Colour.—Reddish, lighter below, with several darker red cross-bars, which disappear with preservation. A reddish stripe at pectoral base. Rows of spots on the scales above the lateral line.

Length.—Up to 470 mm.

Locality.—Natal coast.

This is a peculiar species, apparently confined to a restricted area. It is not known south of Natal, and may eventually prove to extend along the east coast of Africa northwards. It is the most easily identifiable Sparine fish, the shape of the head being immediately characteristic. It is nowhere very plentiful.

Genus *Porcostoma* n.g.

Body ovate, fairly robust. Snout subconical. Eye small. Preorbital deep, completely concealing maxilla. Posterior nostril small, circular.

Mouth moderate, in upper 4, in lower jaw 6 prominent projecting canines, visible when mouth closed; behind those villiform teeth. Molars in 2–3 series in each jaw, sometimes 4 series above.

Thirteen dorsal spines, short. Soft dorsal and anal densely scaly for basal $\frac{1}{3}$–$\frac{1}{2}$. Caudal only slightly emarginate.

Scales small, ctenoid, almost quadrangular, more than 70 series. Preopercle flange only partly scaly along inner margin of flange. Cheek scales small; interorbital scaly, scaling on head to in advance of front eye edge.

Genotype *dentata* Gilchrist and Thompson.

It is remarkable that this peculiar species should ever have been included in either *Pagrus* Cuv. or *Sparus* Linn. It is clearly distinct by full generic rank from all other Sparid fishes. The combination of concealed maxilla, small scales of characteristic shape, 13 dorsal spines, projecting canines, scaly interorbital, circular hind nostril, and almost naked preopercle flange places it by itself.

The genus is endemic and monotypic.

Porcostoma dentata G. & T.

(Pls. XX and XXV and text-fig. 17.)

1908. Gilchrist and Thompson, Ann. S.A. Mus., vol. vi, p. 173.
1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 697.

This species is always very easily identified by the combination of concealed maxilla, projecting canines, 13 dorsal spines, and few scales on preopercle flange. It merits no more than the briefest redescription.

Depth 2·4–2·5, head 3·1–3·2 in body length. Eye 3·7–4·2 in head, 1·5–1·8 in preorbital depth. 4 canines in upper, 6 in lower jaw, villiform teeth behind those. 11–12 gill-rakers. Hind nostril circular, small.

D XIII, 11: 4th and 5th spines longest, 3·2 in head. A III, 8–9: 2nd and 3rd spines subequal. Pectoral equal to head. Ventral 1·8 in head. Caudal with broad round lobes, only gently emarginate.

Scales small, ctenoid. Lateral line tubes very short, stout, with 2–3 tubes behind (Pl. XX, fig. 4). Most body scales sub- or fully quadrangular (Pl. XXV, figs. 6 and 7). l.l. 71–73, l.tr. $\frac{15}{26}$, 9–10 across cheek. Interorbital scaly, scaling on head extends above anterior nostril. Preopercle flange mostly naked, only a few scales along inner margin.

Colour.—Reddish, lighter below, sometimes streaks along the scale rows. A dark bar across the interorbital. The first 8–12 lateral line scales dark, forming a streak. Soft dorsal and anal, pectorals and ventrals with golden tinge.

Length.—Up to 270 mm.

Locality.—Natal to Delagoa Bay, usually in deeper water.

A comparatively scarce species, found in a fairly restricted area.

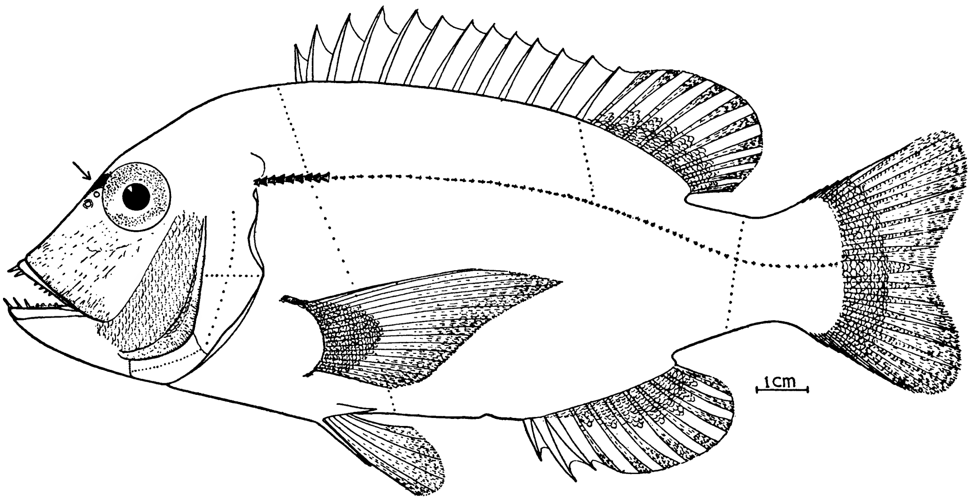


FIG. 17.—*Porcostoma dentata* G. & T.
The rows of dots represent number and disposition of scale rows. The small arrow shows the anterior limit of scaling on head.

Subfamily PAGELLINAE.

Molariform teeth weak but always present. Anterior teeth slight and conical, forming outer series of a band of villiform teeth. Dentition rapto-tritorial but relatively feeble. Mouth small, but rather to very protractile. Premaxillary rami about as long as pedicels. Scales ctenoid. Interorbital naked or scaly. Preopercle flange naked.

Eye moderate to large. Posterior nostril oval or slit-like.

11 or 12 dorsal spines. Soft dorsal and anal naked with low sheath. Caudal deeply forked.

Colour either reddish to bronzy, or else silvery with dark cross-bars.

More or less carnivorous (food chiefly mollusca and crustacea) fishes, most living in shallow, one species normally in deeper water.

Three genera are included here, although *Boopsoidea* Cast. shows considerable divergence from the other two. Nevertheless the type and the nature of the dentition and the protractile mouth fit better with the Pagellinae than with the Sparinae.

The species in this group are not of much commercial significance, but one (*Lithognathus lithognathus* Cuv.) ranks high among game fishes and attains a considerable size.

Key to the Genera of the Pagellinae.

I. Eye large, greater than snout. Molars uniformly small . . . *Boopsoidea.*
II. Eye moderate, not greater than snout. Inner molars enlarged.
  A. Interorbital scaly. 12 dorsal spines. Last dorsal and anal ray enlarged. Posterior nostril circular. Scales with lobate hind margin. Preorbital shallow, notched. Pink or red. Inhabit deep water . . . . *Pagellus.*
  B. Interorbital naked. 11 dorsal spines. Last dorsal and anal ray not enlarged. Posterior nostril slit-like. Scales with rounded hind margin. Preorbital deep, not notched. Silvery, with dark cross-bars. Inhabit shallow water . . . . . *Lithognathus.*

Genus *Boopsoidea* Castlenau.

1933. Fowler, U.S. Nat. Mus. Bull. 100, vol. xii, p. 169.

Body fairly deep, compressed. Eye large, greater than snout and than shallow preorbital. Hind nostril oval. Mouth small, snout fairly blunt Sharp conical (villiform) teeth in bands in both jaws, with outer series somewhat enlarged. Small even molars in 2–3 series in each jaw. 11 dorsal spines; soft dorsal and anal naked with low sheath.

Scales moderate, ctenoid. Interorbital and preopercle flange naked. Colour rosy-bronze, scales with darker edges.

Genotype *inornata* Cast.: monotypic and endemic.

Boopsoidea inornata Castlenau.

(Pls. XXII and XXVIII.)

1933. Fowler, *loc. cit.*, p. 169.

This species does not need detailed redescription. Depth 2·1–2·2, head 3·3 in body length. Eye 2·4–2·7, much greater than very shallow preorbital, and greater than snout. Mouth small, protractile; outer series of teeth slightly larger than inner, slight and caniniform. Gill-rakers 13–14, slender. Air-bladder with small caudal extensions. D XI, 10: spines slender. A III, 11. Pectoral slightly longer than head. Ventral 1·7 in head. Caudal forked. Lateral line tubes very broad (Pl. XXII, fig. 1). Scales ctenoid (Pl. XXVIII, figs. 3 and 6). l.l. 53–56, l.tr. $\frac{8\text{–}9}{15\text{–}16}$, 10–11 rows on cheek. Interorbital naked, scales on head extend to above hind margin of eye. Preopercle flange naked.

Colour.—Bronzy with rosy reflections, lighter below. A brownish blotch on opercle above. Axil of pectoral darkish.

Length.—Up to 300 mm.

Locality.—Cape Peninsula to Natal in shallow water.

This is a characteristic species which appears worthy of generic distinction from all other Sparid fishes. The dentition, large eye, shallow preorbital, and short snout set it apart.

Inornata is generally found in moderate to deepish water among rocks or reefs, and in many localities it occurs in vast numbers. The combination of small mouth and voracious appetite renders this species a pest to anglers, since it is impossible to keep any bait intact for any time when numbers of them are about, and they may be caught only on the very smallest hooks.

Genus *Pagellus* Cuv.

1933. Fowler, U.S. Nat. Mus. Bull. 100, vol. xii, p. 171 (part).

Body elongate, not much compressed. Eye moderate, less than snout. Hind nostril circular. Mouth moderate, snout subconical. Outer conical teeth moderate, form outer series of band of 4–5 rows. Molars biserial, inner posterior larger. Mouth moderately protractile. Preorbital shallow, notched. 12 dorsal spines, fairly slender. Soft dorsal and anal naked, with low sheath.

Scales with lobate hind margin (Pl. XXIX, figs. 1 and 2), ctenoid, moderate. Lateral line tubes very short and wide with two open tubules behind. Interorbital scaly. Preopercle flange naked. Pinkish, with or without cross-bars of deeper hue, but not black or dusky.

Regional genotype (South Africa) *natalensis* Steindachner.

Smallish fishes inhabiting fairly deep water and but rarely entering estuaries.

Generally the species here assigned full generic rank in *Lithognathus* Swainson have been included in *Pagellus* Cuv. It is remarkable that the two groups should ever have been accepted as congeneric, and it is time that Swainson's perfectly valid genus received recognition.

Pagellus natalensis Steindachner.

(Pls. XX and XXIX and text-fig. 18.)

1933. Fowler, *loc. cit.*, p. 172 (References and Synonymy).

Body elongate, fusiform, fairly compressed. Dorsal profile of snout low, with moderate concavity before eyes. Adults sometimes with slight frontal gibbosity. Depth equal to length of head, 2·7–3·1 in length of body. Eye 3–4·1, snout 3, interorbital 3·8–4·1, and postorbital 2·6 in length of head. Eye 1·5–2 times depth of preorbital. Preorbital with notched or emarginate lower margin, maxilla well exposed. Posterior nostril small, circular, high up on snout, nostrils close together. Gill-rakers 10–12 on lower part of anterior arch, slender, about 2 in gill-filaments,

which are 1·6 in eye. Mouth moderate, maxilla extends below anterior border of eye. Anterior caniniform teeth very small, 10–12 in lower jaw, outer teeth larger. Molars moderate, biserial. Jaws only moderately protractile. Margin of preopercle serrate in young, serrae concealed in half-grown and adult stadia.

D XII, 10: inserted behind hind margin of operculum. 3rd–5th spines subequal, or 4th, or 4th and 5th, subequal, longest, 2·9 in head; remainder

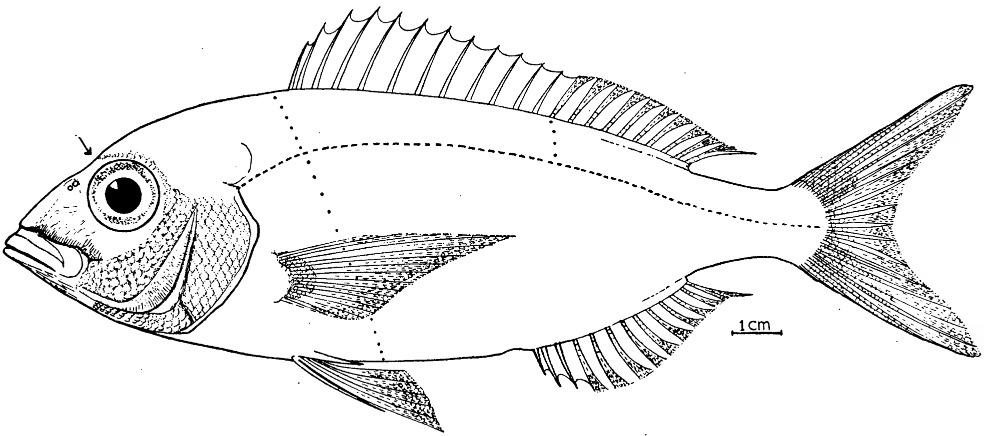


FIG. 18.—*Pagellus natalensis* Stdnr.
The rows of dots represent the number and disposition of scale rows. The small arrow shows the anterior margin of scaling on head.

decrease to the last. First ray but slightly longer than last spine. Edge of soft fin only slightly convex. Last ray enlarged, 3·5 in head, 1·5 times penultimate, reaches almost to caudal base.

A III, 10: 2nd and 3rd spines about equal, shorter than soft rays. Margin of anal fairly convex, 3rd ray longest. Last ray enlarged, about equal to last dorsal ray. Pectoral 1·0–1·1 in head, tip reaches almost above anal origin. Ventrals 1·6–1·7 in head, do not reach vent. Caudal deeply forked, almost lunate, lobes slender.

Scales ctenoid, with lobate hind margin (Pl. XXIX, figs. 1 and 2). Lateral line scales with short wide tube and two tubules behind, each opening by a pore (Pl. XX, fig. 1). l.l. 63–67, l.tr. $\frac{6\text{–}7}{15\text{–}17}$, 6 series across cheek, 7–8 across opercle. Soft dorsal and anal naked, with low scaly sheath. Preopercle flange naked. Interorbital partly scaly; scaling on head extends to above anterior border of eye.

Colour.—Pink or red, lighter below. Sometimes dusky spots above lateral line. Fins rosy.

Length.—Up to 350 mm.

Locality.—Mossel Bay to Madagascar, usually in deep water, up to 75 fathoms.

Not a very common species, but occasionally taken in fair numbers by trawlers on the south coast. Usually does not come close inshore. In the Knysna area, during the summer months, a cold current (50° F.) occasionally comes inshore, and innumerable fishes are numbed and driven ashore. Among the first to appear in the shallow water is *P. natalensis*, sometimes in large numbers.

One specimen from Knysna has a red-brown lateral stripe from above the pectoral base to the caudal peduncle. It is otherwise indistinguishable from other specimens.

Genus *Lithognathus* Swainson.

1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 705 (part).
1933. Fowler, U.S. Nat. Mus. Bull. 100, vol. xii, p. 171 (part).

Body fairly elongate, moderately compressed. Snout long, more or less pointed. Eye rather small, less than snout. Hind nostril slit-like. Conical teeth small (markedly smaller than in *Pagellus*), outer series but little enlarged. Molars biserial smallish, inner posterior larger. Mouth very protractile. Preorbital deep, curved, but not notched.

Eleven dorsal spines, fairly stout. Soft dorsal and anal naked, with low sheath. Scales with rounded hind margin (Pl. XXIX, figs. 3 and 6), ctenoid; lateral line tubes short and wide with many pores behind. Interorbital and preopercle flange naked. Silvery with dark cross-bars.

Genotype *lithognathus* Cuv., endemic.

This genus has not been accepted at full rank. Fowler (*loc. cit.*, 1933) assigned it subgeneric rank in *Pagellus*. Actually there can be no question of its validity. Not only is it distinct from *Pagellus* by constant variation in the naked interorbital, slit-like nostril, the character of the scales, and highly protractile mouth, but in general appearance there is a clear-cut distinction. In colour, habits, and habitat these two genera show wide variation. *Lithognathus* is silvery, lives in comparatively shallow water, and regularly enters and lives in estuaries, feeding chiefly upon small crustacea and mollusca found on mud and sand-banks. *Pagellus* is reddish with faint darker red cross-bars, and rarely ever comes close inshore. The mouths in the two genera are quite different. In *Lithognathus* the mouth has been adapted to rooting in the mud and to the blowing of burrowing crustacea from their holes; the dentition is extremely feeble. In *Pagellus* the mouth is more normal, and the dentition, while weak, is obviously raptorial, and better developed than in *Lithognathus*.

Two species are found in South Africa, one of which is endemic.

Key to the Species.

I.	7 wide cross-bars. 8 anal rays. Lips thick	*lithognathus.*
II.	14 narrow cross-bars. 10 anal rays. Lips moderate . . .	*mormyrus.*

Lithognathus lithognathus Cuv.

1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 705.

This well-known species does not require detailed redescription.

Depth 2·7–3, eye 3(juv.)–7 (ad.), much less than preorbital depth in adults. Snout pointed, lips very thick in adults, mouth very protractile. Teeth small, inner molars largest. 12–14 gill-rakers. D XI, 10; A III, 8. Pectorals 1·4–1·5, ventrals 1·8 in head. Caudal forked. Scales large with rounded free margin, ctenoid. Lateral line tubes moderately long and fairly slender; no pores behind. l.l. 44–51, l.tr. $\frac{5\text{–}6}{13\text{–}15}$, 7–8 rows on cheek. Interorbital naked; scaling on head extends above hind margin of eye, not into the interorbital. Preopercle flange naked.

Colour.—Silvery in all but large adults, which become dusky above, deepening on preservation. 6–7 dark cross-bars visible on fresh specimens in all stadia, but become obsolete in large specimens with preservation. Fins silvery grey.

Length.—Attains a length of 1200 mm. and a weight of over 40 lbs.

Locality.—All round the coast of South Africa from north of Walfisch Bay round the Cape to Natal. Common in all estuaries of the southern part of South Africa.

This is the only member of the Pagellinae of any commercial significance in South Africa. It is seldom taken in large numbers, since the larger fishes appear to be of solitary habit; but fair numbers are at times taken by drag-nets in estuaries. The flesh is usually highly esteemed, being of delicate texture and flavour.

As an angling fish *lithognathus* ranks high in South Africa, and may indeed be classed among the best game fishes of the world and is eagerly sought by anglers.

The long snout and thick lips of *lithognathus* have obviously been produced in response to a special method of securing food, in search of which *lithognathus* penetrates to absurdly shallow water. Certain crustacea construct U-shaped burrows in the mud and sand-banks in estuaries. By blowing vigorously down one limb, one may cause the creature to be expelled forcibly up from the other. The "steenbras" evidently secures food in this manner, and quite frequently the tails of very large fishes may be observed waving above the water on shallow banks. Also the fish

probably blows holes in the sand in search of buried mollusca, which form an important part of its diet.

On occasions large fishes are hooked in water so shallow that the entire dorsal fin and part of the back may be exposed above the water. This species is not particularly timid, and it has been found possible to approach, with caution, to within 15 yards of specimens seeking food after the manner outlined above.

Lithognathus mormyrus Linn.

(Pls. XX and XXIX and text-fig. 19.)

1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 706.

Depth 2·8–2·9, head 2·8–3 in body length. Eye 3–5·0 in head, 1·7–2·2 in snout, and 1·2–1·5 in preorbital depth. Snout fairly sharp, subconical.

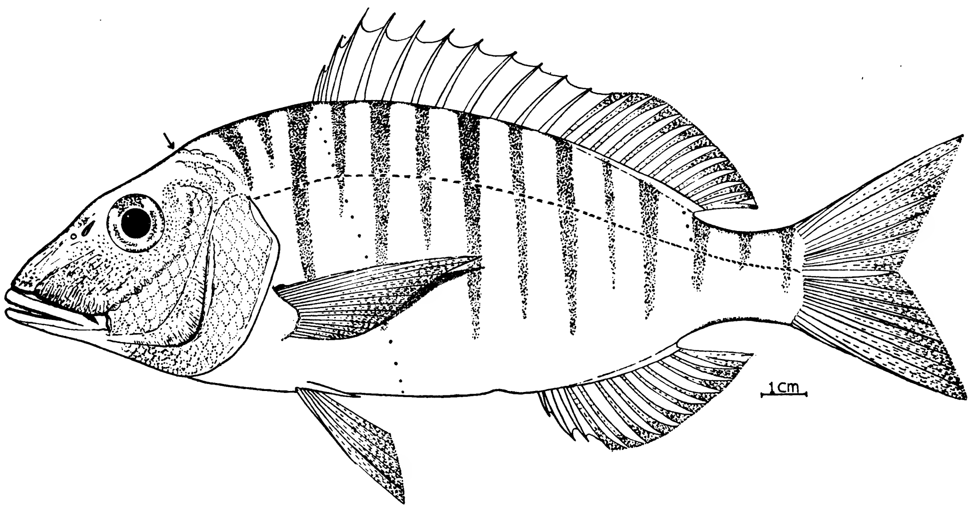


Fig. 19.—*Lithognathus mormyrus* Linn.
The rows of dots represent the number and disposition of scale rows. The small arrow shows the anterior margin of scaling on head.

Mouth very protractile, lips thin. Conical teeth small. Molars in 3–4 series above, 3 series in lower jaw. 14–15 gill-rakers. D XI, 12; A III, 10. Pectorals 1·3–1·4, ventrals 1·8–1·9 in head. Caudal deeply forked.

Scales with rounded hind margin, moderate, ctenoid (Pl. XXIX, figs. 3 and 6). Lateral line tubes short and wide, with two smaller tubules each opening by a pore behind (Pl. XX, fig. 6). l.l. 60–64, l.tr. $\frac{6}{13–14}$, 5–6 rows on cheek. Interorbital naked; scaling on head extends to above behind hind margin of eye. Preopercle flange naked.

Colour.—Silvery, dusky or greyish above, with about 14 narrow cross-bars, fading somewhat with preservation.

Length.—Up to 430 mm.

Locality.—Throughout the South African region entering estuaries. Extends to the Mediterranean; probably all round the coasts of Africa.

This is a well-known species, but never occurs in such numbers as to be of any commercial significance. It frequents sandy areas.

Subfamily Scatharinae.

Anterior teeth incisiform, in a single series, or in bands; outer teeth sometimes lanceolate, continued laterally, but no anterior group of a few enlarged teeth. Molariform teeth sometimes present. Dentition primarily sectorial. Mouth generally small, not or only slightly protractile. Premaxillary rami not or but little longer than pedicels.

Scales ctenoid. Interorbital naked, preopercle flange naked or scaly. Soft dorsal and anal either naked with low sheath, or scaly at base without sheath. Cheeks naked or scaly. Eye moderate; preorbital deep or shallow. 10–11 dorsal spines, usually not very long, moderately stout. Caudal moderately forked. Colour brownish, sometimes with longitudinal stripes.

Herbivorous fishes, of small or moderate size, usually found among rocks in shallowish water, some species common on banks in fairly deep water. Most species exclusively marine, not entering estuaries.

The species in this group are not of very great commercial or angling significance. One or two occur in relatively vast numbers, but are too small, or the flesh is too insipid, to render them of much importance. At some seasons the flesh of some is of rather rank flavour, which is probably due to the graminivorous habit.

No changes in nomenclature or arrangement are proposed in this group, chiefly owing to the recent revision of the main genera by Norman (*vide infra*).

Key to the Genera.

I. Cheeks naked . . . . *Gymnocrotaphus.*

II. Cheeks scaly.

- A. A single series of notched incisors only in each jaw . . *Sarpa.*
- B. Two or more series of teeth in each jaw.
  - X. Outer series of teeth movable, edges crenulate . . *Crenidens.*
  - Y. Outer series of teeth fixed, edges entire.
    - *a.* Some inner teeth lanceolate.
      - *x.* Soft dorsal and anal naked, with low sheath. Preorbital shallow, notched . . . *Spondyliosoma.*
      - *y.* Soft dorsal and anal scaly at base, without sheath. Preorbital deep, entire . . *Pachymetopon.*
    - *b.* All inner teeth obtuse, molariform . . . *Polyamblyodon.*

Genus *Gymnocrotaphus* Günther.

1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 727.

Body ovate, moderately compressed. Eye small. Mouth small with an outer series of curved incisors in each jaw. Behind those one or two rows of subconical teeth and then a wide band of smaller teeth with rounded crowns, the inner series molariform. Posterior nostril slit-like. 10 dorsal spines. Soft dorsal and anal scaly basally, without sheath. Caudal emarginate. Prefrontals produced forward acutely.

Scales moderate, ctenoid. Lateral line tubes moderate, sometimes bifurcate. Cheeks naked; a small oval patch of scales behind eye. Interorbital and preopercle flange naked.

Genotype *curvidens* Günther, monotypic and endemic.

Gymnocrotaphus curvidens Gnthr.

(Text-fig. 20.)

1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 727.

This well-known species can never be confused with any other and so does not need detailed redescription.

Body ovate, normally rather plump and soft. Depth 2–2·3 in body length. Eye 4–4·6 in head, 1·4–2 in preorbital depth. Mouth small,

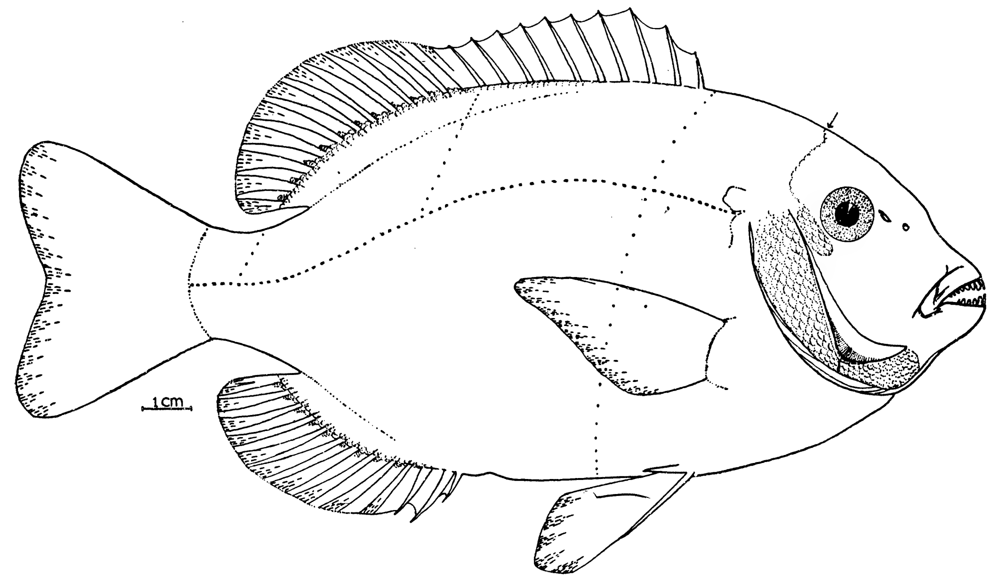


FIG. 20.—*Gymnocrotaphus curvidens* Gnthr.
The rows of dots represent the number and disposition of scale rows. The small arrow shows anterior margin of scaling on head.

scarcely protractile; outer series of enlarged curved incisors, almost exsert; a band of molariform teeth behind. 7–9 gill-rakers.

D X, 12: 3rd spine longest, 3–3·2 in head. A III, 10: soft dorsal and anal rounded. Pectoral 1·1–1·2, ventral 1·3–1·4 in head. Caudal emarginate, lobes broadly rounded.

Scales ctenoid. Lateral line tubes moderate, with oblique branch, or bifurcate and several pores behind. l.l. 64–68, l.tr. $\frac{7\text{–}8}{18\text{–}22}$. Cheeks naked, but a patch of scales in 3–4 series, an eye diameter deep, behind eye. Preopercle flange and interorbital naked. Scales on head extend to above hind third of eye. Soft dorsal and anal without sheath, densely scaly on basal third.

Colour.—Brown or bronzy, slightly lighter below. Iris blue.

Length.—Up to 350 mm.

Locality.—Cape Peninsula to Great Kei Mouth, in shallow water among rocks.

Contrary to usual statements, the inner teeth, while small, are distinctly molariform.

A species well known to the rock angler, but rarely, if ever, taken in any numbers. The flesh is usually delicate and tasty.

This is another rather highly localised species peculiar to South Africa.

Genus *Sarpa* Bonaparte.

1933. Fowler, U.S. Nat. Mus. Bull. 100, vol. xii, p. 181.

Body ovate, rather plump. Eye moderate. Mouth small with but a single series of incisors in each jaw, those in upper jaw notched, in lower jaw pointed, all with strong horizontal roots. No molars. 11 dorsal spines, slender. Soft dorsal and anal naked with very deep sheath. Caudal moderately forked.

Scales small, ctenoid. Cheeks scaly. Interorbital and preopercle flange naked. Air-bladder posteriorly bifurcated into two caudal horns. Peritoneum black.

It is rather doubtful whether this is really a Sparid genus. The overlapping of the maxilla by the premaxilla end is more nominal than real, while the horizontal roots of the teeth and the bifurcated hydrostatic organ are reminiscent of the Kyphosidae. The naked fins are, however, not characteristic of that family.

Temporarily the genus is included here since it has so long been accepted as Sparid, but its relationships will form the subject of later study.

A single species in South Africa.

Sarpa salpa Linnaeus.

1933. Fowler, *loc. cit.*, p. 181.

A well-known species, which does not need detailed redescription. Apparently extends almost right round Africa.

Depth 2·7–3. D XI, 14–15; A III, 13–14. l.l. 71–79, l.tr. $\frac{6}{14\text{–}16}$, 5–6 scales on cheek. 12–14 gill-rakers. Soft anal and dorsal naked, with very heavy scaly sheath.

Colour.—(Alive) Greenish or silvery bronze above, with a few faint light blotches along the back. Numerous narrow golden longitudinal stripes. Axil of pectoral black. Lateral line dark. The golden stripes fade on preservation.

Length.—Up to 450 mm.

This species occurs in large numbers along our coasts, and appears to attain the largest size in the cold waters of the western shores of the Cape Peninsula. Along the south coast it abounds in shallow water among rocks and reefs, and enters estuaries freely. It is regarded as an excellent bait-fish, but the flesh softens rapidly and, being rather strong flavoured, is not much esteemed as food.

Genus *Crenidens* Valenciennes.

1933. Fowler, U.S. Nat. Mus. Bull. 100, vol. xii, p. 201 (Girellidae).

Body ovate, moderately compressed. Eye moderate. Mouth small, in each jaw 2 series of incisors, edges quinquedentate, and behind those several rows of small molars.

11 dorsal spines. Soft dorsal and anal naked with moderate sheath. Caudal forked. Pectoral longer than head. Vertebrae 24 (10 + 14). Scales moderate, cycloid. Cheeks scaly; interorbital and preopercle flange naked. Air-bladder with slight caudal horns. Only the typical species in South Africa.

Fowler (*loc. cit.*, 1933) has placed *Crenidens* in the Girellidae, probably because of the crenulate incisiform teeth. Actually those teeth of *crenidens* are quinquedentate, whereas those of all the Girellidae are tricuspid. Further, in that family the vertebrae number 27 or 28, the pectorals are shorter than the head, there are 13–16 dorsal spines and no molariform teeth. *Crenidens* has 24 vertebrae, pectorals longer than head, 11 dorsal spines, while molariform teeth are present. Fowler, in the diagnosis of *Crenidens* (*loc. cit.*, p. 200), stated "no molar teeth," whereas on the next page he described the species *Crenidens crenidens* Forskäl as having "biserial molars."

Actually it has been found that *Crenidens* has the characteristic groove

in the premaxilla which bears on and overlaps the maxilla externally, so that it cannot be any but a Sparid genus.

Crenidens crenidens Forskäl.

(Pls. XXII and XXVI and text-fig. 21.)

This species does not require detailed redescription.

Body oblong ovate. Depth 2·4–2·5 in body. Eye 3·2–3·6 in head, about 1·5 times preorbital depth. 9–10 gill-rakers. Incisors apically brown, 12–14 in upper, 10–12 in lower jaw.

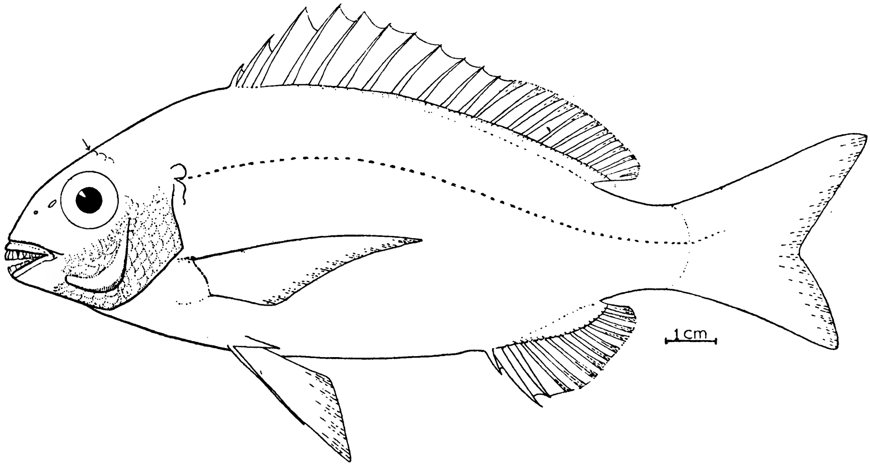


FIG. 21.—*Crenidens crenidens* Forskäl.
The small arrow indicates the anterior margin of the scaling on the head.

D XI, 11: 4th spine longest, 1·9 in head. Soft fin slightly convex. A III, 10: 2nd spine longest. Pectorals 1·2 times, ventrals 1·1 in head. Caudal moderately forked.

Scales cycloid, those above the lateral line with slightly lobate hind margin (Pl. XXVI, figs. 6 and 7). Lateral line tubes stout, slightly strangulated, with two diverging series of pores behind (Pl. XXII, fig. 5). l.l. 55–60, several more on caudal; l.tr. $\frac{5-6}{15-16}$, 3 cheek scales. Interorbital and preopercle flange naked. Scales on head extend to above centre of eye. Soft dorsal and anal naked, with low scaly sheaths.

Colour.—Silvery, greenish blue or olive above. Narrow longitudinal stripes show more clearly on preservation. Axil of pectoral sometimes darkish.

Length.—Up to 260 mm.

Locality.—East London northwards. Extends to the Indian region.

Easily distinguished from all other Sparid fishes by the crenulate incisors. Very young specimens may sometimes be confused with similar stadia of *Austrosparus auriventris* Peters, since the young of the latter have tricuspid incisors. In those cases the number of incisors is diagnostic.

The remaining South African Scatharine fishes, of the genera *Spondyliosoma* Cantor, *Pachymetopon* Günther, and *Polyamblyodon* Norman, have been described in great detail and figured by Norman (Ann. S.A. Mus., 1935, vol. xxxii, pt. 1, pp. 6–21), so that repetition is unnecessary. Keys for the species of those genera are copied from Norman's work.

Genus *Spondyliosoma* Cantor.

1935. Norman, Ann. S.A. Mus., vol. xxxii, p. 6.

Preorbital shallow, notched. Soft dorsal and anal naked, with low sheath. Narrow lanceolate incisors in 4–6 rows in each jaw, outer largest; an inner row obtuse, molariform. 11 dorsal spines. Scales ctenoid, with lobate hind margin.

Regional genotype *emarginatum* Cuv. and Val. Only one species in South Africa.

Spondyliosoma emarginatum C. & V.

(Pls. XXII and XXIX.)

1935. Norman, *loc. cit.*, p. 9, fig. 2.

Depth 2·2–2·6. Eye about equal to snout, 3–4 in head, 2–2·7 times depth of preorbital. Lower margin of preorbital notched. 15–17 gill-rakers.

D XI, 11–13; A III, 10; pectoral equal to head. Scales ctenoid, with lobate hind margin (Pl. XXIX, figs. 4 and 5). Lateral line tubes very wide, with a few large pores behind (Pl. XXII, fig. 2). l.l. 80–92, l.tr. 14–15 above. Preopercle flange and interorbital naked.

Colour.—Brownish; when alive, several very narrow, faint golden longitudinal stripes. Dorsal, anal, and ventrals darkish (in males only?). Extends from Saldanha Bay round the coast of South Africa to Natal and Madagascar.

Length.—Up to 300 mm.

According to Norman, *S. microlepis* G. & T. is a synonym.

Often found in tidal estuaries.

Genus *Pachymetopon* Günther.

1935. Norman, Ann. S.A. Mus., vol. xxxii, p. 11.

Preorbital moderately deep, lower margin not notched. Soft dorsal and anal scaly on basal third, but no sheath. Outer teeth broader and

fewer than in *Spondyliosoma*, no molariform teeth. 10–11 dorsal spines. Scales ctenoid. Five species in South Africa, one of doubtful validity (*q.v.*).

Key to the Species. (After Norman.)

I. 36–44 teeth in outer row of lower jaw. Preorbital depth less than eye. 13–16 gill-rakers.
- A. Preopercle flange naked. l.l. 60–66. Pectoral not longer than head.
  - X. 40–44 teeth in outer row of lower jaw. 1st dorsal spine $\frac{1}{2}$–$\frac{2}{3}$ eye . . . . *blochii*
  - Y. 36 teeth in outer row of lower jaw. 1st dorsal spine $\frac{4}{5}$ eye . . . . *canescens*.
- B. Preopercle flange scaly. l.l. 80–86. Pectoral longer than head . . . . *aeneum*.

II. 22 teeth in outer row of upper jaw. Preorbital depth equal to eye. 10–11 gill-rakers.
- A. Depth 2·3 in length . . . . *grande*.
- B. Depth 1·8–2·0 in length . . . . *glaucum*.

Pachymetopon blochii Val.

(Pls. XXII, XXVIII, and XXIX.)

1935. Norman, *loc. cit.*, p. 12, fig. 3.

Depth 2·3–2·5 in length. Eye 3–5·2 in head, 0·9–1·5 times preorbital depth. End of maxilla exposed. 30–36 teeth in outer row of upper, 40–44 in outer row of lower jaw. 4–5 inner rows not as high. 13–14 gill-rakers. D X–XI, 11–12; A III, 10. Scales ctenoid, with semi-lobate hind margin (Pl. XXVIII, fig. 9; and Pl. XXIX, fig. 9). Lateral line tubes very wide and short with two lots of two pores behind (Pl. XXII, fig. 3). l.l.60–65, l.tr. $\frac{9\text{–}10}{18\text{–}20}$, 8–9 cheek scales. Scaling on head extends to above behind middle of eye. Preopercle flange and interorbital naked. Brownish; lighter below; sometimes bronzy.

Length.—Up to 450 mm.

Locality.—South-West African coast round the Cape, occasional specimens along the coast as far as Algoa Bay.

Pachymetopon canescens Norman.

1935. Norman, *loc. cit.*, p. 14, pl. ii.

Very closely related to *P. blochi*, and differs only in minor characters. Norman does not appear to have investigated the possibility of sexual dimorphism in this case; or at any rate he has made no statement about it.

(The following description compiled.) Depth 2·5 in body. Eye 4 in head, 1·4 times preorbital depth (the figure of *canescens, loc. cit.* above, shows eye 1·25 times preorbital depth). Preorbital almost concealing maxilla. 26–28 outer teeth in upper, 36 in lower jaw. D X–XI, 10–11: 1st spine about $\frac{1}{5}$ eye diameter. A III, 9–10. l.l. 65, l.tr. 10 above. 8–9 scales on cheek. Interorbital and preopercle flange naked. Scales on head as for *P. blochi.*

Yellow brown, patch below eye, one on operculum, darkish areas along upper half of side; lighter below. Longitudinal rows of dots along sides, some dots on fins.

Locality.—Kalk Bay.

Length.—Up to 275 mm.

Only two specimens are known, one of more or less unknown locality (holotype).

I have seen, at Lamberts Bay, "Hottentots" somewhat lighter in colour, with darker blotches, among the commoner brown specimens. They may have been *P. canescens.*

Pachymetopon aeneum Gilchrist and Thompson.

(Pls. XXII and XXIX.)

1935. Norman, Ann. S.A. Mus., vol. xxxii, p. 15, fig. 4.

Depth 2·3–2·6 in body. Eye 3·5–4·5 in head, 1·3–1·8 times depth of preorbital. A prominent bulge at interorbital, and the general effect of the snout is simocephalous. 15 gill-rakers. 30–36 outer teeth in upper, 36–40 in lower jaw. D XI, 11; A III, 10. Pectoral 1·2 times head. l.l. 80–86, l.tr. $\frac{10\text{–}11}{21\text{–}23}$, 10 cheek scales. Interorbital with scaling on upper portion. Preopercle flange scaly. Scales almost cycloid, ctenae on ventral scales only very feeble (Pl. XXIX, figs. 7 and 8). Lateral line tubes narrow and long, with one or two pores behind (Pl. XXII, fig. 4).

Colour bronzy or brown, preserved specimens sometimes show longitudinal streaks.

Length.—Up to 510 mm.

Locality.—False Bay to Natal.

The combination of small cycloid or weakly ctenoid scales, the scaly preopercle flange, and several other features distinguish this from the other species of *Pachymetopon*, so as almost to merit separation by full generic rank.

This is a well-known angling fish, being taken not only from the shore among rocks but also from boats on banks down to 30 fathoms. The flesh is firm and of good flavour and highly esteemed. Specimens of

This is not quite accurate much applies to

10–12 lbs. in weight are not uncommon. The species bites freely and fights well when hooked, and so is esteemed by anglers.

At nights large specimens may occasionally be found in numbers in quite shallow water among rocks, and they are often secured by spearing.

Pachymetopon grande Günther.

1935. Norman, *loc. cit.*, p. 17, fig. 5.

(Compiled description.)

Slight interorbital prominence. Depth 2·3 in body. Eye 4 in head, equal to preorbital depth. Maxilla not concealed. 18–20 teeth in outer row of upper jaw, 22 in lower. 10–11 gill-rakers. D XI, 11; A III, 10–11. Pectoral 1·4 times head. l.l. 80, l.tr. 11 above, 7 cheek scales. Preopercle flange naked. Interorbital naked, scales on head extend above front third of eye.

Brownish, with narrow lines along lower half of side. Fins mostly dark.

Length.—Up to 520 mm.

Locality.—South-Eastern Cape to Madagascar.

Quite [redacted] plentiful in South African waters.

Pachymetopon glaucum Norman.

Quite invalid

1935. Norman, *loc. cit.*, p. 20, fig. 6.

This species is very close indeed to *P. grande*, and has been founded on a single specimen. Both forms are evidently rather rare, and again in this case sexual dimorphism may account for the variations. Certainly the differences are not very great.

A real Museum specimen

(Description compiled.)

Depth 1·8 in body (the figure shows depth 2 in body; Norman, *loc. cit.* above). Eye 3·7 in head, about equal to preorbital depth. Maxilla not concealed. 11 gill-rakers. 22 teeth in outer row in each jaw. D XI, 11; A III, 11. Pectoral 1·33 times head. l.l. 85, l.tr. above 10–11, 7 cheek scales. Preopercle flange naked. Interorbital naked, scaling on head to above front third of eye. Dark grey above, lighter below. Narrow lines along lower half of side. Fins dark.

Length.—310 mm.

Locality.—East London.

A very doubtful species indeed, the sole differences stated being that *glaucum* has a deeper body and a shorter pectoral than *grande*. A specimen recently obtained from East London renders the validity of *glaucum* still more doubtful. This specimen, an adult male, 470 mm. total length, has depth 2·18, head 4·0 in body. Eye 4·8 in head, 1·3 in preorbital depth.

26 upper and 24 lower teeth. 10 gill-rakers. D XI, 11; A III, 10. Pectoral 1·33 times head, ventrals 1·25 in head. Lateral line scales 80. Interorbital naked.

This agrees in the main with the diagnosis of *grande*, and leaves *glaucum* to rest solely on the greater depth of the body, a feature of doubtful validity, for in these fishes it might be due to distension produced by intestinal decomposition which occurs soon after death unless preservatives are employed.

Genus *Polyamblyodon* Norman.

1935. Norman, Ann. S.A. Mus., vol. xxxii, p. 21.

Very closely allied with the preceding genus, but differs chiefly in the dentition : the teeth of the inner rows small and rounded, molariform; the outer teeth strong, curved, compressed.

It is of interest to note that Norman evidently regards the dentition in the Sparidae of such great significance as to found a genus upon that character alone.

Polyamblyodon germanum Barnard.

1934. Barnard, Ann. Mag. Nat. Hist. (10), vol. xiii, p. 230, fig. 2 (head and teeth).

1935. Norman, *loc. cit.*, p. 21.

Interorbital prominent, gibbous. Depth 2·5 in body. Eye 4–4·3 in head, 1·2 in preorbital depth. 16 gill-rakers. D XI, 11; A III, 11. l.l. 71, l.tr. $\frac{9}{29}$, 8 cheek scales. Preopercle flange and interorbital naked, scales on head extending to above hind nostril. In outer rows in upper jaw 40 teeth, 52 in lower. 7 rows of small molariform teeth.

Only two specimens known, 368 and 375 mm. length, from Durban.

Evidently a very rare species.

Family DENTICIDAE.

Body compressed, elongate or elongate-oval. Mouth moderate to large, usually fairly protractile. Maxilla usually partly exposed. Teeth all acute, anteriorly always a small group of separated, large, curved, fang-like teeth, truly caniniform. Laterally one or more rows of acute teeth, no molariform teeth. No palatal or lingual teeth. Outer teeth implanted in sockets, replacement by vertical succession.

Gills 4, a slit behind the 4th. Gill-rakers usually lanceolate, sometimes short and blade-like (*Petrus*), in moderate number. Gill-membranes free from isthmus. Pseudobranchiae present. Air-bladder usually simple. Pyloric caeca few.

Dorsal single, seldom deeply notched. 3 anal spines, 2nd and 3rd usually subequal. Ventrals of a spine and 5 rays, with axillary scale. Caudal forked.

Scales usually ctenoid; sometimes cycloid scales also present (*Gymnocranius*). Soft dorsal and anal usually naked with low or moderate sheath, sometimes basally scaly without sheath (*Petrus*).

Skull with well-developed occipital and parietal crests. Premaxillary pedicels usually short, much shorter than the relatively slender rami (see fig. 2). The premaxilla in its distal extremity has some form of groove in the upper margin, in which rests part of the lower edge of the maxilla, as described for the Sparidae. Dentaries moderate. A strong subocular shelf from the 2nd suborbital. Vertebrae 24 (10 + 14). Parapophyses from the 3rd precaudal, and the 1st rib sessile.

The type genus occurs in the Atlantic and has been held to extend also into the Indo-Pacific. That view is not held here, a decision which is in keeping with the finding in the related Sparidae, namely, that the Atlantic and the Indo-Pacific forms in the family are generically distinct. The seven South African species in this family were placed in the single genus *Dentex* Cuv. by Barnard (Ann. S.A. Mus., 1927, vol. xxi, pp. 711 ff.), who gave *Gymnocranius* Klunz. only subgeneric rank. Fowler (1933, U.S. Nat. Mus., vol. xii, pp. 116 ff.) placed most of our species in *Dentex* Cuv., but accepted *Gymnocranius* Klunz. as valid, with one species in South Africa.

Examination has shown that there is every justification for regarding all the South African species as distinct generically from *Dentex* Cuv. In that genus the scales on the head do not, or scarcely, reach the interorbital region, while the dorsal and anal are quite naked with a very low sheath. The South African species all have the interorbital scaly, the scales usually covering the whole extent of that region to well in advance of the eye, while the soft dorsal and anal are either basally scaly without sheath, or else have very heavy sheaths. Jordan and Thompson (Proc. U.S. Nat. Mus., 1912, vol. xli, pp. 570 ff.) had actually observed the significance of the divergence of the Indo-Pacific form from that of the typical genus, and had proposed at that time the genus *Taius* for the former species. Actually, as will be seen, *Polysteganus* Klunz. must have priority, and *Taius* becomes a synonym.

Fowler's treatment of the group of the species of *Dentex* Cuv. is characterised by most lamentable carelessness or inaccuracy. His diagnosis of the genus (*loc. cit.*, 1933, p. 117) alone contains numerous characters which are most emphatically not applicable to all our species, while he has included in the list of species some which cannot possibly belong there (*cf.* p. 125, *Dentex peronii* Val. and *Dentex matsubarae* J. & E.). In his key to the

species (*loc. cit.*, p. 118), subgenus *Dentex* has "Frontal scales not extending forward before eye," whereas the descriptions of the species in that group in most cases have "Predorsal scales forward to nostrils," which examination of the specimens would show to be the case.

The seven South African species have been divided into four genera, the proposed arrangement being as follows:—

Genus.	*Species.*
Gymnocranius Klunzinger	*robinsoni* G. & T.
Petrus n.g.*	*rupestris* Valenciennes * (type).
Polysteganus Klunzinger	*coeruleopunctatus* Klunz.
	undulosus Regan.*
	argyrozona Valenciennes.*
	praeorbitalis Günther.*
Cheimerius n.g.	*nufar* Valenciennes (type).

Genera and species marked * are endemic.

The South African species in this family are all mostly carnivorous and live in fairly deep water. Only one comes regularly close inshore or enters estuaries. Some occur in large numbers and are of considerable economic significance in South Africa. Most are some shade of red or pink, sometimes with cross-bars or stripes. Only one species attains a large size, mostly fishes of moderate size.

Key to the Genera of the Denticidae.

I. Interorbital and preopercle flange quite naked. 10 dorsal spines . *Gymnocranius.* Not Denticidae (Pentapodidae)

II. Interorbital and preopercle flange at least partly scaly. 11–12 dorsal spines.

A. 1st and 2nd dorsal spines very short, abruptly shorter than 3rd. 3rd and some following spines elongate, filamentous . . . . *Cheimerius.*

B. Dorsal spines graduated, first 2 not abruptly shorter and none filamentous.

X. Scales on head do not extend above front margin of eye, nor right across interorbital. Soft dorsal and anal naked, with very low sheath (Atlantic only) . (*Dentex.*)

Y. Scales on head extend beyond above front margin of eye and completely cover interorbital. Soft dorsal and anal scaly at base or with marked sheath. (Indian and Indo-Pacific.)

a. 12 dorsal spines. Gill-rakers lanceolate. Soft dorsal and anal naked with sheath . . *Polysteganus.*

b. 11 dorsal spines. Gill-rakers short and compressed. Soft dorsal and anal scaly without sheath . . . . *Petrus.*

Genus *Gymnocranius* Klunzinger.

1870. Klunzinger, Synop. Fisch. d. Roth. Meer., p. 764.
1933. Fowler, U.S. Nat. Mus. Bull. 100, vol. xii, p. 129.

Body compressed, deep. Eye rather large, preorbital deep. Mouth moderate. Conical teeth in several series in jaws; anteriorly 4–6 enlarged, caniniform. Gill-rakers few. 10 dorsal spines, moderate. Soft dorsal and anal naked, with basal sheath. Caudal forked. Posterior nostril rounded, subequal to anterior. Scales almost cycloid, at most very feebly denticulate, rather large, about 50 series. Preopercle flange and interorbital naked. Air-bladder bifurcate, with short caudal horns.

This genus has not generally been accepted as valid in regard to the South African fauna. Actually, even a superficial examination of *G. robinsoni* shows immediately that it must receive distinction by full generic rank from all other Denticid fishes in South Africa. The naked interorbital and preopercle flange, the large eye, the shape of the head and body, the dentition, and the almost cycloid scales are more than sufficient to establish the validity of *Gymnocranius*.

Only one species, *G. robinsoni* G. & T., in South Africa. It is of no commercial significance there.

Gymnocranius robinsoni Gilchrist and Thompson.

(Pls. XXI and XXVII.)

1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 712.

Depth 2·3–2·7, head 3·0–3·1 in length of body. Eye 2·8–3·4 in head, about equal to preorbital depth. Posterior nostril small, circular. Mouth moderate, maxilla exposed. Canines rather small, irregular; inner villiform teeth in bands.

D X, 10–11; A III, 9–10. Caudal forked.

Scales above lateral line cycloid, those below on hinder part of body with faint signs of granulations (Pl. XXVII, figs. 1 and 2). Lateral line tubes moderate, rather oblique, no pores behind (Pl. XXI, fig. 2). l.l. 46–50, l.tr. $\frac{6\text{–}7}{18\text{–}19}$, 4 or 5 series on cheek. Whole of interorbital and preopercle flange scaleless. Soft dorsal and anal scaleless, with sheath. Stated to be silvery. Specimens when preserved would appear to have been pink or red in life, stated also to have wavy blue lines across snout, cheek, and opercle; dorsal and anal rosy yellow, caudal and pectoral pinkish. These colours fade on preservation.

Length.—Up to 400 mm.

Locality.—Natal.

Extends up the east coast of Africa to the Red Sea.

This species appears to be very rare in our waters; even in Natal few specimens are taken.

May easily be distinguished from all other South African Denticid fishes by the naked cranium and preopercle flange, only 10 dorsal spines and the relatively large eye, besides other features.

Certainly does not fall with the Atlantic *Dentex* Cuv.

Genus *Cheimerius* n.g.

Body fairly compressed. Snout moderately sharp. Eye moderate; preorbital about equal to eye. Posterior nostril oval. Mouth moderate. Villiform teeth in narrow bands in each jaw, become more obtuse posteriorly, the inner hinder series having rounded crowns, verging on the molariform. Anteriorly in each jaw 4 strong caniniform teeth, occasionally also 2 smaller median. Gill-rakers lanceolate.

12 dorsal spines, the first 2 short, 3rd abruptly longer, filamentous; also the 4th–6th filamentous but shorter than the 3rd. 1st ventral ray prolonged. Colour red, with faint cross-bars.

Scales ctenoid, moderate. Preopercle flange mostly naked. Interorbital only partly scaly, scaling not right across and coming to a point anteriorly. Soft dorsal and anal naked with low sheath. Lateral line tubes more or less bifurcate (Pl. IV, fig. 3).

Type *C. nufar* Valenciennes, monotypic.

This genus has the same standing in the Denticidae as has *Argyrops* Swainson in the Sparidae. Not only is *Cheimerius* distinguished from other Denticid genera by numerous taxonomic characters, but its habits (*q.v.*) also set it apart.

The single species ranges from the Cape along the coast of Africa to the Indo-Chinese region.

Cheimerius nufar Valenciennes.

(Pls. XXI and XXVII and text-fig. 22.)

Dentex miles Gilchrist and Thompson, Ann. S.A. Mus., 1908, vol. vi, p. 155; Fowler, Proc. Ac. Nat. Sci. Phil., 1925, vol. lxxvii, p. 240.

Dentex albus Gilchrist and Thompson, Mar. Biol. Rep. S.A., 1914, No. 2, p. 128, fig.

Dentex filosus (non Valenciennes) Gilchrist, Ann. Durb. Mus., 1917, vol. i, pt. 4, p. 356; Barnard, Ann. S.A. Mus., 1927, vol. xxi, p. 715; Fowler, U.S. Nat. Mus. Bull. 100, 1933, vol. xii, p. 126.

Dentex nufar Day, Fishes of India, 1878–1888, pl. xxxiv, fig. 4 (not in text, no description).

Dentex variabilis Valenciennes, Hist. Nat. Poiss., 1830, vol. vi, p. 241 (Red Sea).

Polysteganus nufar (Ehrenberg), Klunzinger, Synopsis d. Fische d. Rot. Meer., 1870, p. 764.

Dentex nufar Valenciennes, Hist. Nat. Poiss., 1830, p. 240; Ruppell, Neue Wirbel., 1835, p. 115; Fowler, Hong-Kong Nat. Hist., 1931, p. 171; Fowler, U.S. Nat. Mus. Bull. 100, 1933, vol. xii, p. 127.

Dentex rupestris (non Val.) Fowler, 1925, *loc. cit.*, p. 239.

Body ovate, moderately deep and compressed. Dorsal profile of snout even and fairly low. Snout moderately sharp, subconical. Depth 2·3–2·6,

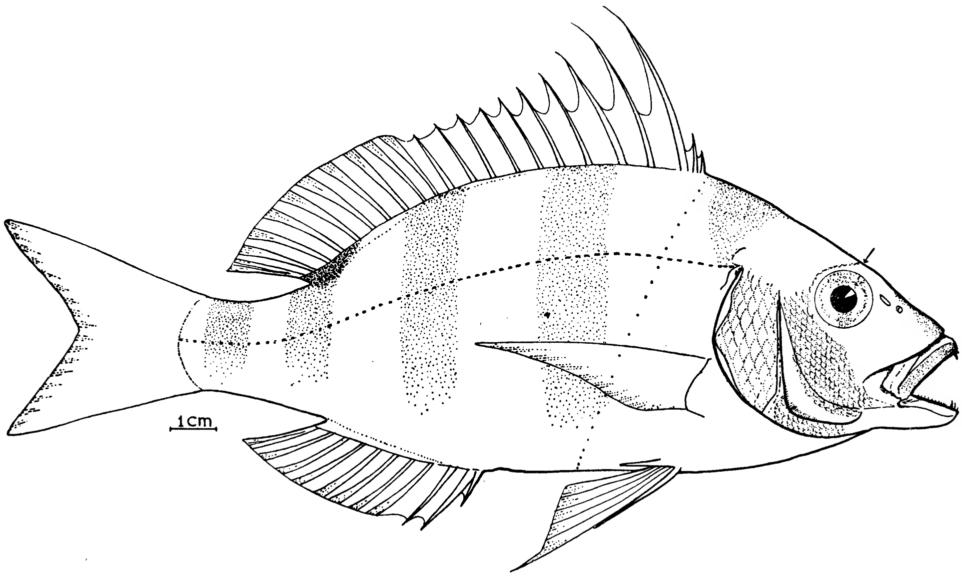


FIG. 22.—*Cheimerius nufar* Valenciennes.
The rows of dots represent number and disposition of scale rows. The small arrow shows anterior limit of scaling on head.

length of head 3–3·4 in length of body. Eye 3(juv.)–4·6, snout 2·3–2·6, interorbital 3·2–3·5, and postorbital 2·4–2·5 in length of head. Preorbital depth slightly less than (juv.) to slightly greater than (ad.) eye diameter. Posterior nostril oval. Preopercle margin serrate round angle and lower margin in juveniles. Lower margin of preorbital straight in juveniles, gently convex ventrally in half-grown and adult stadia. Mouth moderate, maxilla extends to below anterior part of eye. Premaxillary pedicels longer than in *Polysteganus* Klunz. but not as long as rami. 4–6 fairly strong canines in the front of each jaw, the inner pair always small, often absent, except in juveniles. In each jaw a narrow band of small villiform

teeth, outer lateral series enlarged, inner posterior series rather obtuse. Maxilla largely concealed, but end exposed. Jaws about equal. Gill-rakers 13–14, lanceolate, 2 in gill filaments, which are 2 in eye.

D XII, 10 (one species out of thirty examined had D XI, 11): inserted behind hind opercular margin. 1st spine 3·5–4 ; 2nd 2 in eye; 3rd abruptly longer, filamentous, length varies with age. In juveniles it is shorter than in half-grown specimens, in which it is longest, slightly longer than head to 1·4 in head. In large adults the 3rd spine appears to be relatively shorter, but that is probably due to damage. The 3rd–7th spines are generally filamentous, the 3rd always longest; 3rd spine 0·9–1·4, 4th 1·4–1·6, 5th 1·7–1·9, 6th 2·0–2·1, 12th 3·2–3·3 in head. Soft rays slightly higher than last spine, about 2·9–3 in head. Base of soft fin 1·6–1·7 in base of spinous. Edge of soft fin gently convex, last ray not shortened, slightly longer than penultimate.

A III, 8: inserted below the 10th dorsal spine. 1st spine 1·2 in eye, 2nd and 3rd subequal, 1·4 times eye. Edge of soft fin gently convex.

Pectoral 1·0–1·2 (juv.) in head, tip reaches above anal origin, ventrals with 1st ray filamentous, reach to anal origin, 1·3–1·4 in head. Caudal forked.

Scales moderate, ctenoid (Pl. XXVII, figs. 3 and 8). Lateral line tubes moderate; posteriorly 2 tubules, each opening externally by a pore (Pl. XXI, fig. 3). l.l. 59–63, l.tr. $\frac{8}{16}$, 8–9 cheek scales. Preopercle flange mostly naked, usually a few series of scales round inner lower margin. Interorbital partly scaly, scaling does not extend right across the interorbital, and comes to a point above or behind the front margin of the eye. Soft dorsal and anal naked, with low sheath.

Colour.—(Just after death) Rosy, lighter below, with 5 rather faint, broad, darker red cross-bars. Anal margin, ventrals, and lower caudal lobe blue. A bronze bar vertically through iris over pupil. Hind margin of caudal dusky. A red-brown blotch at the base of the hind dorsal rays. (Preserved) More or less uniform reddish brown (cross-bars fade rapidly).

Length.—Up to 600 mm.

Locality.—From the Cape Peninsula to Natal, entering estuaries occasionally when young. Extends to the Red Sea, India, and China. Will probably be found through the whole Indo-Pacific.

There has been considerable confusion over this somewhat variable species, which in South Africa has hitherto been regarded as identical with the Atlantic species *filosus* Valenciennes. The latter apparently has the 2nd dorsal spine filamentous, D XI, 11, and longitudinal red bands, but otherwise does not differ very widely from *nufar*. *filosus* does not

apparently extend farther south than Angola and certainly does not occur in South Africa.

Day's lapse in providing a figure of *D. nufar* without reference in the text is rather curious (*vide supra*, Day). His figure leaves no doubt as to the identity of the specimen.

There appears to be little doubt that *miles* G. & T. and *albus* G. & T. are synonyms. The type specimens have been examined and compared with others, and while variations in the lengths of the first 3 dorsal spines occur, they hardly justify the maintenance of a species distinct from *nufar*. *nufar* is rather variable in body shape and in the lengths of the dorsal spines.

The genus has been named from a characteristic of the type, at least in South Africa. *nufar* appears in our tidal rivers just before bad weather at sea. At Knysna, should that species be taken in the nets, one may be certain of a storm at sea within twenty-four hours. Individuals remain in the river during the stormy weather and occasionally for a few days after, but I have never heard of a specimen being taken in the river during a long fine spell.

This species generally appears to be of solitary habit.

Genus *Polysteganus* Klunzinger.

1890. Klunzinger, Synopsis d. Fische d. Roth. Meer., p. 763.
1912. Jordan and Thompson, Proc. U.S. Nat. Mus., vol. xli, p. 570 (*Taius*).

Body fairly compressed, snout blunt or conical. Eye moderate. Preorbital depth less than or greater than eye. Posterior nostril usually oval. Mouth moderate. Anterior canines either moderate and subequal or with outer much-enlarged and inner smaller pair. Lateral teeth either slight and fang-like or rather heavy but acute. A few small villiform teeth behind the canines in each jaw. Gill-rakers lanceolate, fairly numerous.

12 dorsal spines, graduated, no abrupt differentiation, none filamentous.

Scales ctenoid, moderate, hind margin sometimes lobate. Preopercle flange completely scaly. Interorbital scaly right across, scaling to above in advance of eye margin, front edge of scaling rounded. Soft dorsal and anal naked, with marked sheath. Lateral line tubes with 2 smaller tubes behind or diverging series of pores giving appearance of bifurcate tubes.

Genotype *coeruleopunctatus* Klunzinger.

Colour usually reddish, generally with some blue longitudinal markings.

Of all our Denticid fishes these might perhaps be held as closest to the Atlantic *Dentex* Cuv. As previously indicated, however, there are numerous differences which justify maintaining the Indo-Pacific forms as separate by full generic rank.

The four South African species of this genus fall into three distinct subgroups, here accorded subgeneric rank, an admitted compromise. An examination of material from the whole Indo-Pacific may ultimately establish them as full genera.

These fishes are generally found in moderately to fairly deep water and are all of economic significance.

Key to the Species.

I. Preorbital depth usually less than eye, only occasionally greater in largest adults. Scales above lateral line more than half the depth of those below. Eye rather large.

A. (*Polysteganus*).

Head length less than body depth. Hind margin of maxilla partly concealed beneath preorbital. Body ovate, not very elongate. Jaws about equal. Canines weak, upper 4 subequal. 13–16 gill-rakers. Posterior nostril oval. Pectoral as long as or longer than head.

X. Rows of dots on each scale row on upper part of body. Pectoral longer than head . . *coeruleopunctatus.*

Y. 4–6 wavy longitudinal stripes and a blotch below the 6th dorsal spine. Pectoral equal to head *undulosus.*

B. (*Argyrozona*).

Head length equal to body depth. Hind margin of maxilla completely exposed. Body elongate. Lower jaw projects strongly. Canines not equal, in each jaw outer pair very strong, inner feeble. 18–20 gill-rakers. Posterior nostril circular. Pectoral much shorter than head . . . . *argyrozona.*

II. (*Axineceps*).

Preorbital always much deeper than eye. Scales above lateral line less than half depth of those below. Eye rather small *praeorbitalis.*

Subgenus *Polysteganus* Klunzinger.

Polysteganus coeruleopunctatus Klunzinger.

(Pls. XXII and XXVIII)

Polysteganus coeruleopunctatus Klunzinger, Synopsis Fische d. Roth. Meer., 1870, p. 763; Fowler, U.S. Nat. Mus. Bull. 100, 1933, vol. xii, p. 128 (Red Sea).

Dentex lineopunctatus Boulenger, Ann. S.A. Mus., 1903, vol. iii, pt. 2, p. 66, pl. vi; Barnard, Ann. S.A. Mus., 1927, vol. xxi, p. 718 (Natal); Fowler, 1933, *loc. cit.* above, p. 121.

Dentex natalensis Gilchrist and Thompson, Ann. S.A. Mus., 1908–11, vol. vi, p. 156 (Natal); and Fowler, Proc. Ac. Nat. Sci. Phil., 1925, vol. lxxvii, p. 240 (Delagoa Bay).

Dorsal profile of snout evenly convex, not very steep. Depth 2·3–2·5, length of head 3·1–3·5 in length of body. Eye 3–4·1, snout 2·3–3·0, interorbital 3–3·2, and postorbital part of head 2·3–2·4 in length of head. Preorbital depth 1·3–1·6 in eye, lower margin of preorbital gently convex. not concealing maxilla. Posterior nostril oval. Preopercle margin round angle and lower margin feebly serrate in smaller specimens. Mouth rather small, maxilla extends below anterior margin of eye, jaws equal. Canines moderate, 4 in upper, 6 in lower jaw, subequal. Outer lateral teeth broadly conical, hinder rather obtuse. A few series of weak villiform teeth behind the canines. Gill-rakers lanceolate, 12–13 on lower limb of anterior arch.

D XII, 10: inserted behind hind margin of opercle. 1st spine 4, 2nd 2·5, 3rd 2·1, 4th and 5th 1·6, 6th 2·0, last 2·8 in length of head. Soft rays slightly higher than last spine, edge of fin gently convex. Base of soft fin 2·2 in base of spinous.

A III, 8: inserted below the base of the 1st dorsal ray. 1st spine 1·2 in eye, 2nd and 3rd subequal, 1·2 times eye. Soft rays higher than spines, edge gently convex.

Pectoral 1·2 times head, tip reaches above base of 3rd anal spine. Ventrals 1·3 in head, reach to vent. Caudal deeply forked, lobes long.

Scales ctenoid, moderate, those above the lateral line more than half width of those below (Pl. XXVIII, figs. 7 and 8). Lateral line tubes short, moderate, 2 small tubes posteriorly, each ending in a pore, and each with another pore behind (Pl. XXII, fig. 6). l.l. 52–56, l.tr. $\frac{7}{17}$ (advance of dorsal origin back), 5–6 above lateral line below anterior dorsal spines. 7–8 series on cheek. Flange of preopercle scaly, but broad naked outer margin. Interorbital scaly, scales extend to above anterior nostril. Soft dorsal and anal naked, with moderate sheath.

Colour.—Reddish, with blue grey shade above. All scale rows above lateral line show as series of blue spots, one on each scale, forming curved rows above shoulder, more or less straight posteriorly and below the lateral line. Ventrals dark violet. Iris bronzy.

Length.—Up to 400 mm.

Locality.—Natal to Delagoa Bay. Extends to the Red Sea.

It is perhaps venturesome to unite two species without having compared the original types, but in this case there is little doubt that *lineopunctatus* Boulenger is a synonym of *coeruleopunctatus* Klunzinger. The few differences between specimens of the former and the description of the latter are not of great significance. *coeruleopunctatus* was stated to have l.l. 50, l.tr. $\frac{5\text{–}6}{16}$, and eye greater than interorbital. *lineopunctatus* has l.l. 52–56,

l.tr. $\frac{7}{17}$, and an eye about equal to the interorbital. Otherwise the description of the former fits the latter exactly. In specimens of *lineopunctatus* there are 7 scales above the lateral line to the origin of the dorsal, but only 5–6 between the lateral line and the anterior part of the spinous dorsal.

P. coeruleopunctatus is somewhat variable in body shape and in the arrangement of the rows of dots. It may be indicated that Boulenger's figure (*loc. cit.*, pl. vi, above) of the type of *lineopunctatus* agrees in hardly any important particular with the description. The text gives eye in head 3, eye in snout 1·0, head in body 3·0, depth in body 2·3, whereas the figure shows eye in head 3·6, eye in snout 1·6, head in body 2·7, and depth in body 2·6. There are other inaccuracies also. *P. natalensis* G. & T. is certainly synonymous and was founded probably because of the inaccuracies in the original description of *lineopunctatus* indicated above.

coeruleopunctatus probably occurs along the coast of Africa from Natal to the Red Sea. It appears to some extent to be migratory; at any rate it is more plentiful in Natal during the winter months, when it is of reasonable economic significance.

Polysteganus undulosus Regan.

(Pls. XXI and XXVIII and text-fig. 23.)

1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 719, fig. (outline of head of adult).

1935. Fowler, Proc. Ac. Nat. Sci. Phil., vol. lxxxvii, p. 390 (*Dentex filosus*).

Dorsal profile evenly convex in juveniles: adults develop nuchal gibbosity; believed to be in males only.

Depth 2·5–2·9, length of head 3·2–3·6 in length of body. Eye 3·1 (juv.)–5·5, snout 3·1–3·5 in length of head. Eye 2·2–1 times depth of preorbital, only in very large adults is the preorbital depth equal to or even slightly more than eye. Posterior nostril oval. Preopercle margin weakly serrate round angle in juveniles. Mouth small, maxilla extends below anterior border of orbit, or not quite so far. Lower margin of preorbital somewhat undulate, conceals upper portion of hind end of maxilla. Jaws about equal. 4 upper canines subequal, rather feeble. 6 lower canines weak, median pair small. Lateral teeth curved, fang-like, more slender than those of *coeruleopunctatus*. A small band of villiform teeth behind canines in each jaw. 14–16 gill-rakers, short, 3·5 in gill-filaments, which are 2 in eye.

D XII, 10: originates behind opercular margin. Spines moderate, 4th and 5th subequal, longest, 2–2·2 in head. Soft rays slightly longer than last spine, edge of fin gently rounded.

A III, 8–9: inserted below the base of the 1st anal ray. Edge of soft fin gently rounded. Pectoral equal to head, just reaches above anal origin. Ventrals 1·4–1·5 in head, do not reach vent. Caudal well forked.

Scales ctenoid, mostly with more or less lobate hind margin (Pl. XXVIII, figs. 1 and 2). Lateral line tubes fairly stout, with 2 posterior tubules and indistinct pores (Pl. XXI, fig. 5). l.l. 58–62, l.tr. $\frac{9\text{–}10}{19\text{–}20}$, 9–11 scales on cheek. Preopercle flange scaly with very narrow naked margin, scales

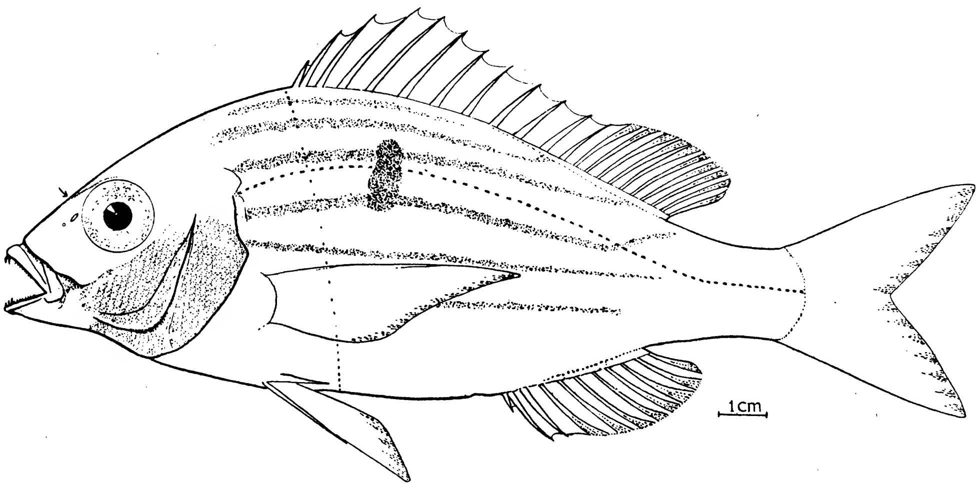


FIG. 23.—*Polysteganus undulosus* Regan. (Juvenile.)
The rows of dots shows number of scale rows. The small arrow indicates anterior margin of scaling on head.

sometimes partly lost with age. Interorbital scaly, scaling on head extends above anterior nostril. Soft dorsal and anal naked with low sheath.

Colour.—Reddish, to white below; bronzy-blue iridescence along back. 4–6 wavy, longitudinal, narrow, blue streaks along upper part of side, and a vertically elongate blue-black blotch across the lateral line below the base of the 5th–6th dorsal spine. Fins variously bluish, pink, or violet. Colours just after death are exceedingly beautiful. Preserved specimens fade to a brown-grey, and the lines and the blotch show blue-black.

Length.—Up to 1000 mm.

Locality.—Table Bay to Natal, most plentiful on the Agulhas Bank.

A well-known and highly esteemed angling and table fish. Usually frequents rather deep water, but occasionally shoals come inshore and numbers are taken by rock anglers from the deeper water.

Argyrozona new subgenus.

As defined in the key to the species of *Polysteganus* Klunz. Also, the hind upper margin of the maxilla is pointed and not covered by the preorbital.

Polysteganus argyrozona Valenciennes.

(Pls. XXI and XXVII and text-fig. 2.)

1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 717 (*Dentex argyrozona*).

This species is so well known and so easily recognised by the protruding lower jaw, the acute end of the exposed maxilla, the widely spaced canines, the inner pair small, the outer very large, and the relatively low long head with flat profile of snout, as not to need detailed redescription.

Depth 2·9–3·2, equals head length. Eye 3·6–4·8 in head, 1·2 in interorbital, and 1·2–1·5 in snout, 1·6–2·0 times depth of preorbital. Snout pointed, subconical, dorsal profile low, almost straight. Posterior nostril larger than anterior, almost circular. Mouth fairly large, maxilla extends below anterior fourth of eye. Whole of distal end of maxilla exposed, upper hinder angle rather acute. Teeth markedly variable in size. Outer canines rather large, inner pair small, all widely spaced. Lateral teeth fang-like, slender, variable. An inner slight band of villiform teeth (fig. 1). 18–20 gill-rakers, slender, 1·4 in gill filaments, which are 2·1 in eye.

D XII, 10: inserted behind hind end of opercle. Spines slender, 4th and 5th longest, subequal, 2·7–2·8 in head. Edge of soft fin gently rounded. A III, 8: inserted below the base of the 1st dorsal ray. Pectorals 1·3–1·4 in head, do not reach near anal origin. Ventrals 2·1–2·2 in head, tip reaches half-way to anal origin. Caudal forked.

Scales moderate, ctenoid, hind margin markedly lobate (Pl. XXVII, figs. 6 and 7). Lateral line tubes short and stout, with 2 large pores behind (Pl. XXI, fig. 4). l.l. 59–62, l.tr. $\frac{7\text{–}8}{18\text{–}19}$, 7–8 cheek scales. Preopercle flange mostly scaly, fairly broad naked margin. Interorbital scaly, scales extend to before above anterior nostril. Soft dorsal and anal naked, with low sheath.

Colour.—Silvery rose-red, lighter below. Just after death several bright longitudinal bands show. Fins pink or rosy.

Length.—Up to 800 mm.

Locality.—Table Bay to Natal, down to 90 fathoms.

Almost certainly *argyrozona* will eventually receive distinction by full generic rank from all other South African fishes. The long low head, the strong canines, the circular hind nostril, the peculiar scales, and the

fully exposed maxilla end, of which the upper angle is characteristic in being acutely produced, are all distinctive.

Economically an important fish; usually taken in large numbers by line boats, chiefly during the winter months. In False Bay large numbers of the juvenile and half-grown fishes, known as "Doppies," are taken on lines from boats, sometimes from the rocks in deepish waters. Professional fishermen of False Bay have long maintained that the "Doppie" and the "Silver-fish" are different species, but an examination of a series reveals no differences to justify their view.

Axineceps new subgenus.

As defined in the key to the species of *Polysteganus* Klunz. Easily distinguished by the very long "face," the deep preorbital.

Polysteganus praeorbitalis Günther.

(Pls. XXI and XXVIII and text-fig. 24.)

1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 714.

1933. Fowler, U.S. Nat. Mus. Bull. 100, vol. xii, p. 119.

Dorsal profile of snout steep. Nape trenchant. Head characteristic, with long "face" due to deep preorbital.

Depth 2·5–2·8, length of head 3–3·2 in length of body. Eye 4·6–7·0, snout 2·1–2·5, interorbital 4·8–5, and postorbital 2·4 in length of head. Eye 1·6–2·0 in preorbital depth. Preopercle margin feebly serrate in juveniles. Mouth fairly large, maxilla extends to below anterior nostril. Lower jaw projects somewhat. In upper jaw 4 canines, widely spaced, outer pair large, inner smaller. In lower jaw 6, widely spaced, outer 2 pairs subequal, not as large as outer of upper jaw, inner pair smaller. Lateral teeth conical and fairly stout. An inner narrow band of fine conical teeth in each jaw. 15–16 gill-rakers on lower limb of anterior arch, slender. Posterior nostril oval.

D XII, 10: inserted just behind opercular margin. 1st spine 5·4–5·8, 2nd 3·2, 3rd 2·6, 4th and 5th subequal, 2·4–2·5 in head. Base of soft fin half that of spinous. Soft rays little higher than last spines, edge of fin gently rounded. A III, 8: inserted below the base of the 1st dorsal ray. Edge of fin gently convex. Pectoral 1–1·2 in head, tip reaches just beyond anal origin. Ventrals 1·7 in head, do not reach vent.

Scales ctenoid (Pl. XXVIII, figs. 4 and 5), those above the lateral line of diameter less than half of those on flanks. Lateral line tubes narrow, oblique, with 2 diverging series of pores behind (Pl. XXI, fig. 6). l.l. 59–63, l.tr. $\frac{11\text{–}12}{16}$, 11–12 cheek scales. Preopercle flange scaly, only narrow

margin naked. Scales on opercle very small. Interorbital completely scaly, scaling on head extends to above anterior nostril. Soft dorsal and anal naked, with deep and heavy scaly sheath, much heavier than in any other species of *Polysteganus* Klunz.

Colour.—(Just after death) Reddish with yellow tinge; a bluish band along dorsal base. Faint series of bluish dots along body. A bluish

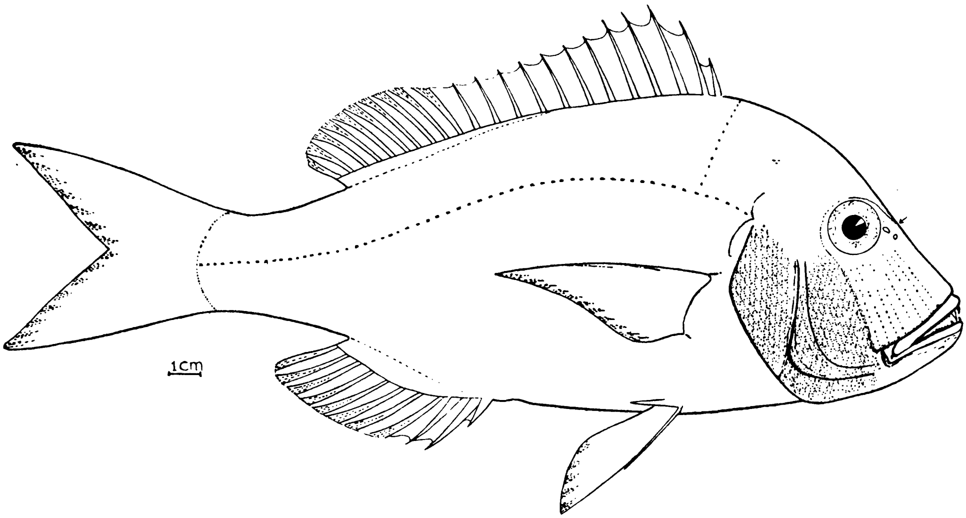


FIG 24.—*Polysteganus praeorbitalis* Günther.
The rows of dots show number and disposition of scale rows. The small arrow shows anterior margin of scaling on head.

streak above and at side of eye. Fins pink or yellow. Preserved specimens usually fade to uniform light red-brown, longitudinal lines showing on the scale rows.

Length.—Up to 500 mm.

Locality.—Algoa Bay to Natal and Zululand, in moderately deep water, down to 50 fathoms.

P. praeorbitalis can never be confused with any other known species from South Africa. It is the Denticid analogue of the Sparid *Chrysoblephus anglicus* G. & T., both having the deep preorbital, but the latter has a more abrupt profile of the snout and molariform teeth.

This species is taken on lines from boats in fairly deep water and is generally more plentiful during the winter months.

Genus *Petrus* n.g.

Body oblong-elongate, fairly compressed. Eye rather small. Preorbital depth greater than eye. Prefrontals usually enlarged, forming a

prominent antorbital ridge. Posterior nostril oval. Mouth large, canines very strong, also lateral teeth. Gill-rakers few, short, wide, laminate (fig. 25). 11 dorsal spines, graduated.

Scales ctenoid, moderate, those above the lateral line less than half width of those below. Interorbital scaly, but scaling not continuous across full extent, comes to an apex scarcely in advance of eye. Preopercle limb only partly scaly. Soft dorsal and anal with heavy fleshy bases, without basal sheaths, and densely scaly basally. Cheek scales very small.

Genotype *rupestris* Valenciennes, monotypic and endemic.

It is remarkable that this genus has not previously been proposed. The peculiar gill-rakers, so different from the usual lanceolate shape characteristic of all other South African members of the family, would alone almost justify the step. In addition is the nature of the soft dorsal and anal fins. There is no basal sheath, the bases of the rays being elevated in a fleshy base above the dorsal profile, and that base and the basal portion of the rays themselves are densely scaly. Certainly *Petrus* can never be held identical with *Dentex* Cuv. nor with any other South African genera of the Denticidae. Other supporting features are the 11 dorsal spines, the nature of the interorbital scaling, the very small cheek scales, and the enlarged prefrontals.

Petrus rupestris Valenciennes.

(Pls. XXI and XXVII and text-fig. 25.)

1927. Barnard, Ann. S.A. Mus., vol. xxi, p. 713.

Dorsal profile of snout fairly abrupt, antorbital ridges prominent. Depth 2·9–3·1, length of head 3–3·2 in length of body. Eye 4(juv.)–8, snout 1·8–2·1, interorbital 3·5–4, and postorbital 2·8 in length of head. Eye 1·4–2·1 in preorbital depth. Lower margin of preorbital slightly undulate. Posterior nostril oval. Preopercle margin round angle feebly serrate in juveniles. Mouth rather large, maxilla end not entirely concealed beneath preorbital. Maxilla extends to almost below anterior nostril. Jaws equal, in upper 4 canines, outer large, inner smaller, in lower 4–6, hinder larger. Fine teeth in a narrow band in each jaw, inner hinder obtuse, almost molariform. Outer lateral teeth conical. Gill-rakers short, laminate, 8–9 on lower limb of anterior arch (fig. 25).

D XI, 10–11: inserted above behind hind opercular margin. Spines fairly stout. 1st 7–7·4, 2nd 5·5, 3rd 3·7, 4th and 5th longest, 3·2 in head. Soft rays longer than last spine, longest 3·1 in head, edge of fin gently convex. Base of soft fin 2·2 in base of spinous.

A III, 8: inserted below the base of the 2nd dorsal ray. 2nd spine

much shorter than 3rd, but slightly stouter. Pectoral 1·2–1·4 in head, does not reach above vent. Ventrals 2·2 in head, do not reach vent. Caudal moderately forked.

Scales moderate, ctenoid (Pl. XXVII, figs. 4 and 5), those above the lateral line less than half the width of those below. Lateral line tubes oblique and fairly slender, with one or more large pores behind (Pl. XXI, fig. 1). l.l. 57–63, l.tr. $\frac{11\text{–}12}{19\text{–}20}$, 17–18 series on cheek. Preopercle flange partly scaly, a wide margin naked. Interorbital partly scaly, scales on head come to a point above or just beyond above the anterior margin of the eye.

Colour.—Red to bronzy, with metallic sheen above, lighter below.

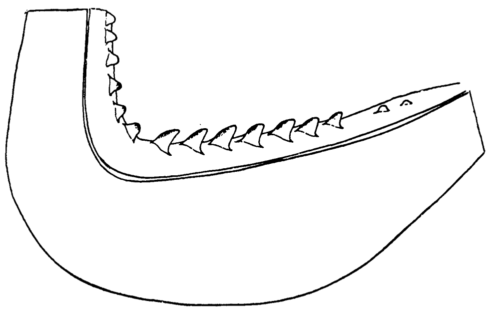


FIG. 25.—First gill-arch of *Petrus rupestris* Val., from specimen 725 mm. total length.

Jaws with yellow tinge. A dark interorbital band, tending to fade. Fins variably reddish.

Length.—Up to 1800 mm.

Locality.—Cape Peninsula to Natal, chiefly on rocky banks. Occasionally enters the mouths of deeper tidal rivers in pursuit of food.

A well-known species which merits full generic distinction from all other Denticid fishes. In many respects it stands as the Denticid analogue of the Sparid *Cymatoceps nasutus* Cast. Both are solitary species of almost similar habits and habitat, which grow to a large size.

P. rupestris ranks high among the angling fishes of South Africa, the capture of a large specimen being the ambition of most rodsters. Specimens of over 130 lbs. have been brought to the scale, but the species is stated to attain a much larger size. Old fishermen of the Agulhas Bank generally agree that the "Red Steenbras" grows to a length of over 6 feet and attains a weight computed at 300 lbs. or even more. *rupestris* is stated to be exceedingly vicious, and cases have been reported of swimmers having been attacked by large specimens. I have known a specimen just landed to snap off the top of a man's finger.

I wish to express my gratitude to the Research Grant Board of South Africa (Carnegie Fund) for generous financial assistance. Also to Dr. Barnard, Assistant Director of the S.A. Museum, for his continual kindness in making copies of figures and extracts from literature not available here. To Dr. Barnard, Colonel Norman of the British Museum, and Dr. de Beaufort, Director of the Zoological Museum, Amsterdam, for the loan of valuable material. Also to Mr. Bell Marley, Principal Fisheries Officer of Natal, without whose aid I should have found it exceedingly difficult to secure some of the rarer Natal species. And to many other friends whose enthusiasm has secured valuable specimens.

To Miss Rothmann, M.Sc., I am indebted for the preparation of text-figs. 1 and 2.

ALBANY MUSEUM,
GRAHAMSTOWN,
May 1937.

EXPLANATION OF LEGENDS TO PLATES.

PLATES XVIII–XXII.—LATERAL LINE SCALES.

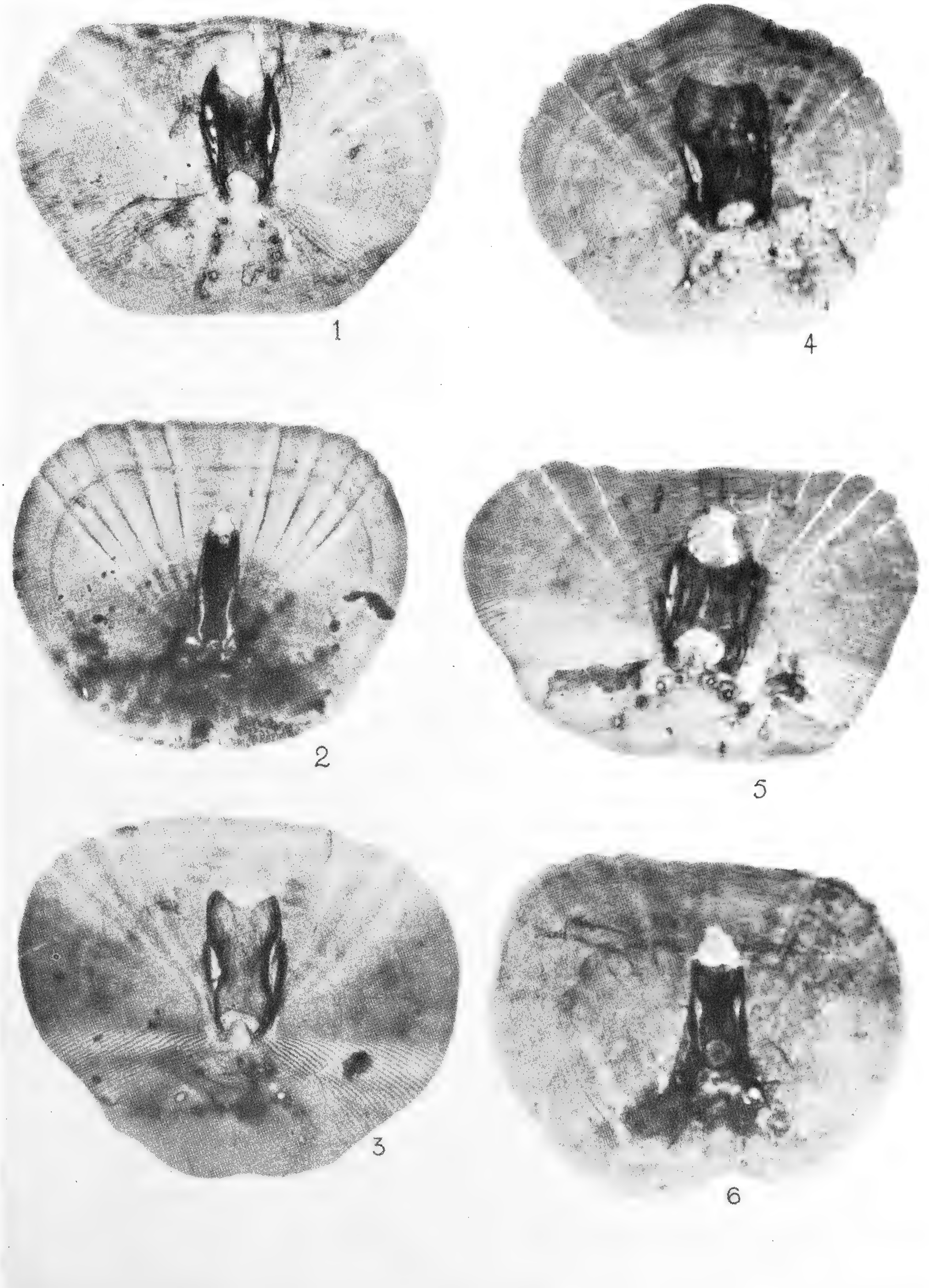
E.g. "1. *Austrosparus auriventris* Peters, 7th (180). × 13," indicates that fig. 1 shows the 7th lateral line scale of that species, taken from a specimen 180 mm. standard length, and that the linear magnification is 13.

PLATES XXIII–XXIX.—ORDINARY SCALES.

In all cases scales A are taken from midway between the anterior part of the base of the spinous dorsal and the lateral line. Scales B are taken from midway between the lateral line and the origin of the anal fin.

E.g. "1. *Austrosparus auriventris* Peters, A (180). × 8," indicates that fig. 1 shows a scale of that species from above the lateral line below the origin of the spinous dorsal, taken from a specimen 180 mm. standard length, and that the linear magnification is 8.

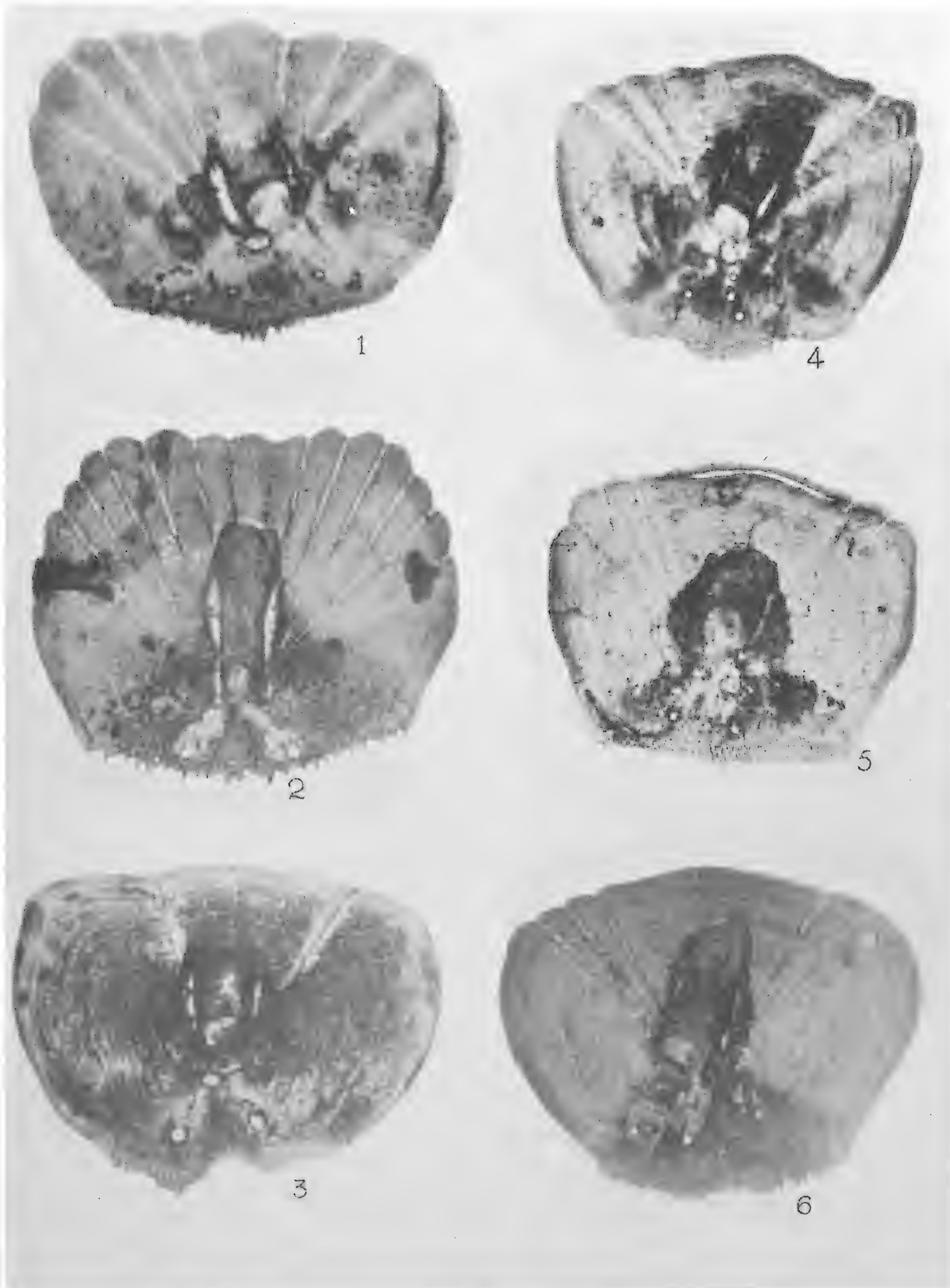
In all cases the posterior margin of the scale is below.



Lateral line scales of Sparid Fishes. Posterior margin below.

1. *Austrosparus auriventris* Peters, 7th (180). ×13.
2. *Acanthopagrus berda* Forsk., 15th (180). ×7·5.
3. *Austrosparus sarba* Forsk., 7th (190). ×11.
4. *Sparodon durbanensis* Cast., 20th (170). ×10.
5. *Austrosparus globiceps* Cuv., 12th (135). ×16.
6. *Acanthopagrus bifasciatus* Forsk., 10th (165). ×9.

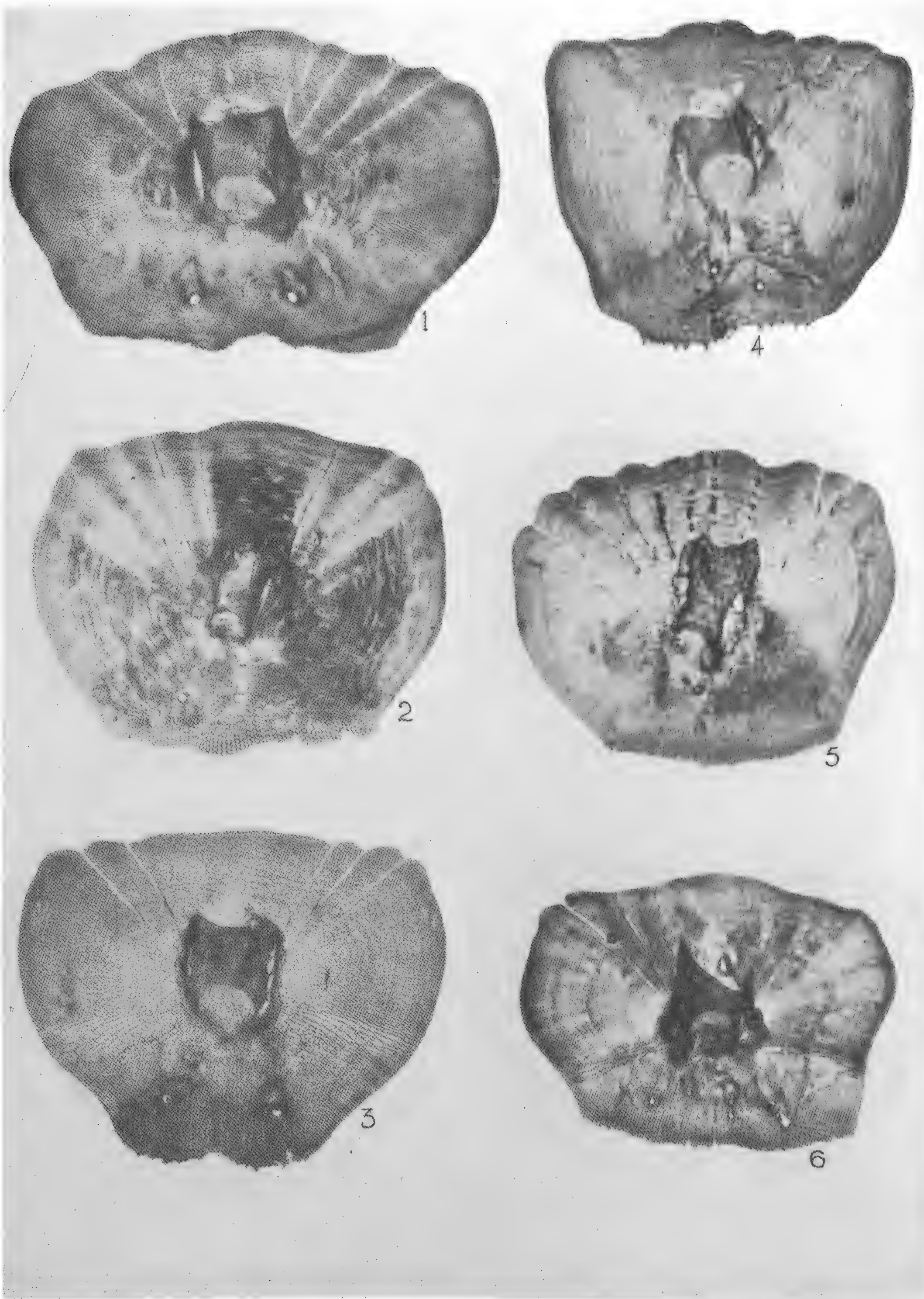
J. L. B. Smith. *Neill & Co., Ltd.*



Lateral line scales of Sparid Fishes. Posterior margin below.

1. *Diplodus sargus* Linn., 45th (175). ×15.
2. *Diplodus trifasciatus* Raf., 56th (150). ×17.
3. *Pterogymnus laniarius* Cuv., 18th (290). ×8.
4. *Chrysoblephus anglicus* G. and T., 15th (315). ×9.
5. *Chrysoblephus laticeps* Cuv., 15th (350). ×8.
6. *Chrysoblephus gibbiceps* Cuv., 12th (220). ×9.

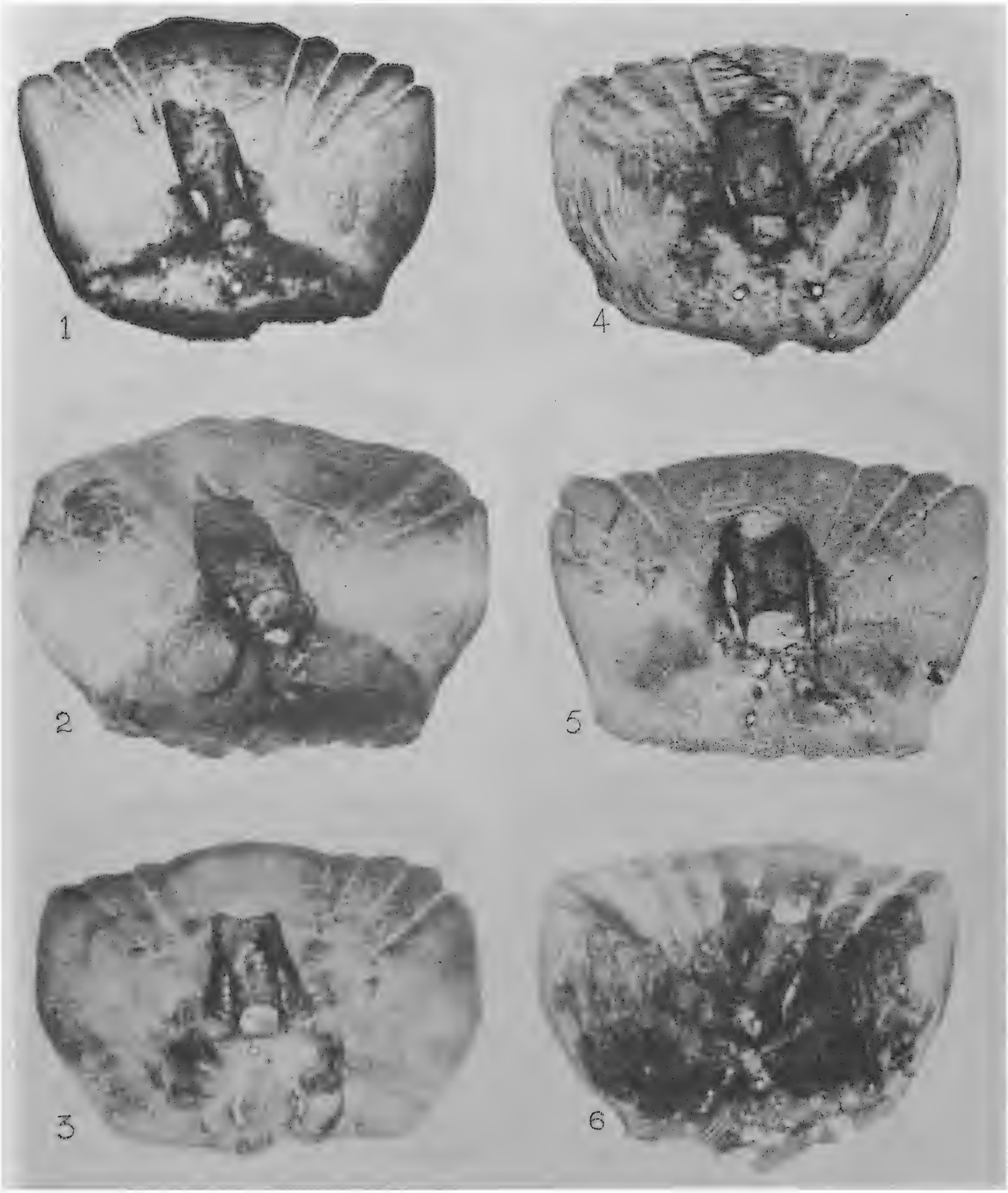
J. L. B. Smith. *Neill & Co., Ltd.*



Lateral line scales of Sparid Fishes. Posterior margin below.

1. *Pagellus natalensis* Stndr., 7th (175). 12.
2. *Chrysoblephus cristiceps* Cuv., 10th (300). ×7.
3. *Argyrops spinifer* Forsk., 10th (110). ×16.
4. *Porcostoma dentata* G. and T., 30th (230). ×21.
5. *Cymatoceps nasutus* Cast., 20th (280). ×8·5.
6. *Lithognathus mormyrus* Linn., 9th (240). ×11.

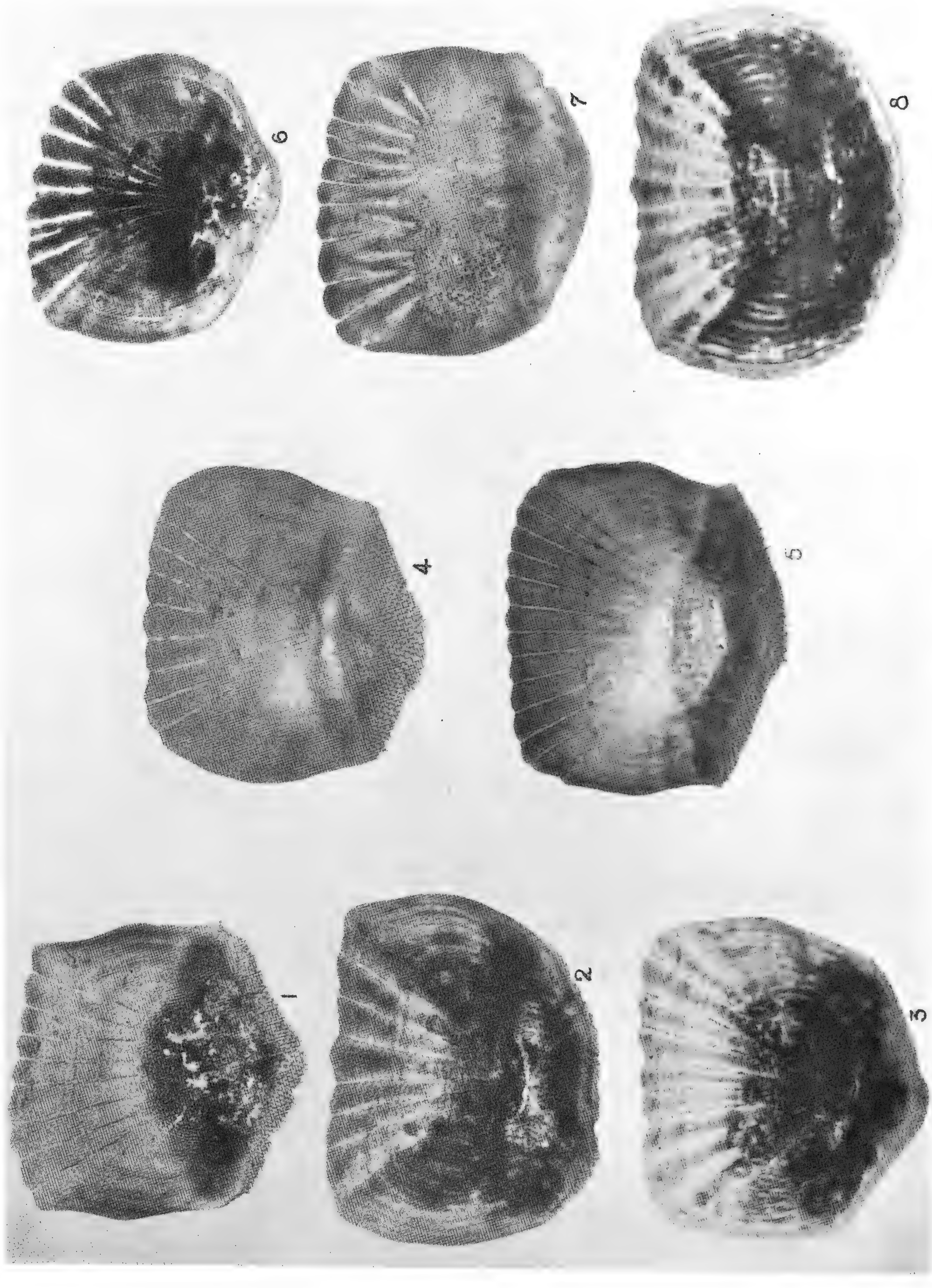
J. L. B. Smith *Neill & Co., Ltd.*



Lateral line scales of Sparid and Denticid Fishes.

1. *Petrus rupestris* Val., 15th (450). ×7.
2. *Gymnocranius robinsoni* G. and T., 16th (300). ×7.
3. *Cheimerius nufar* Val., 15th (250). ×9.
4. *Polysteganus argyrozona* Val., 10th (200). ×9.
5. *Polysteganus undulosus* Rgn., 10th (200). ×13.
6. *Polysteganus praeorbitalis* Gnthr., 10th (300). ×8.

J. L. B. Smith. *Neill & Co., Ltd.*

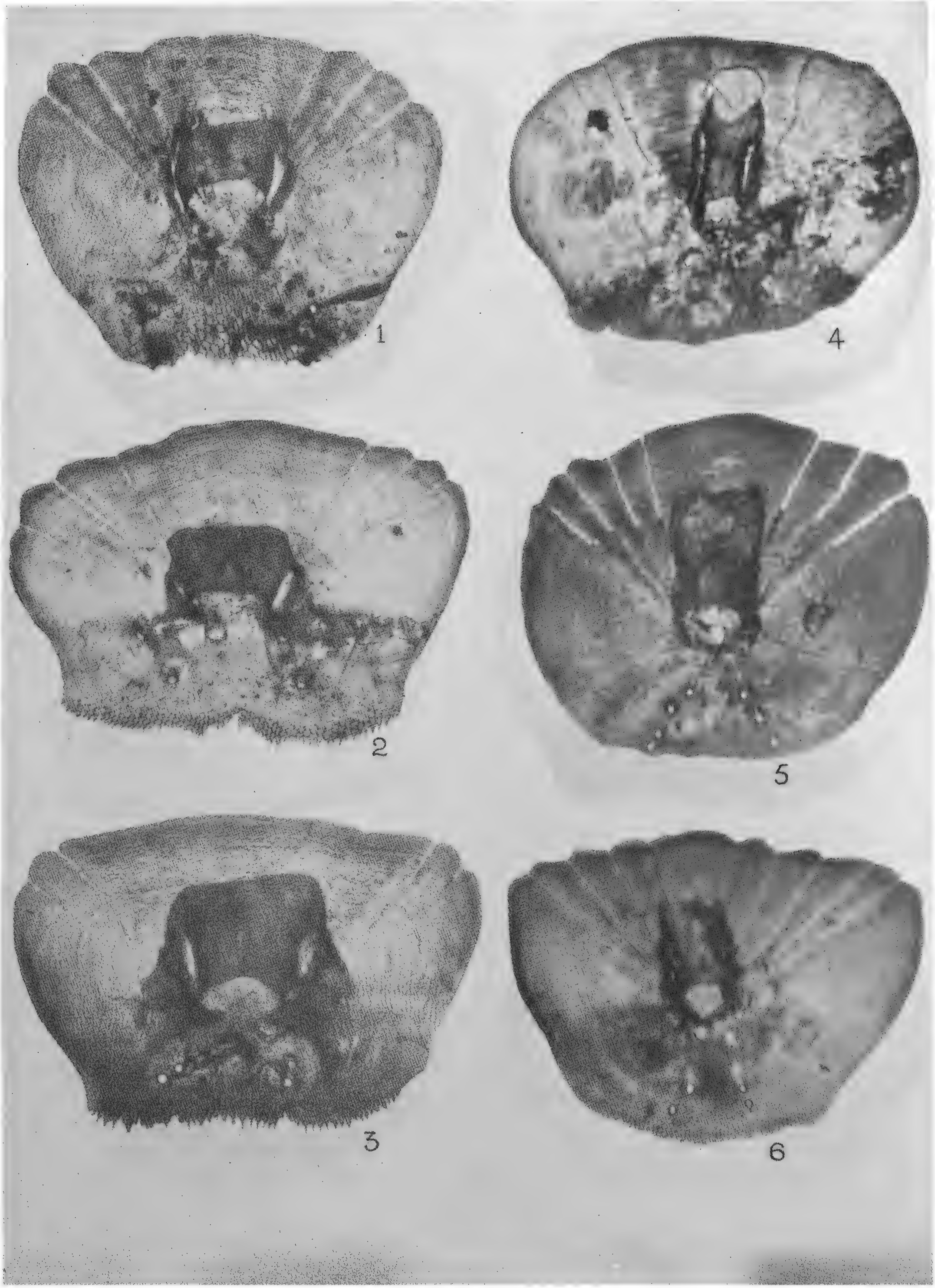


Scales of Sparid Fishes.

1. *Chrysoblephus laticeps* Cuv., A. (150). ×9.
2. *Chrysoblephus laticeps* Cuv., B. (350). ×6.
3. *Chrysoblephus cristiceps* Cuv., B. (300). ×5.
4. *Chrysoblephus gibbiceps* Cuv., A. (220). ×9.
5. *Chrysoblephus gibbiceps* Cuv., B. (220). ×7.
6. *Crenidens crenidens* Forsk., A. (135). ×7·5.
7. *Crenidens crenidens* Forsk., B. (135). ×6·5.
8. *Chrysoblephus cristiceps* Cuv., A. (300). ×5·5.

J. L. B. Smith.

Neill & Co., Ltd.



Lateral line scales of Sparid and Denticid Fishes.

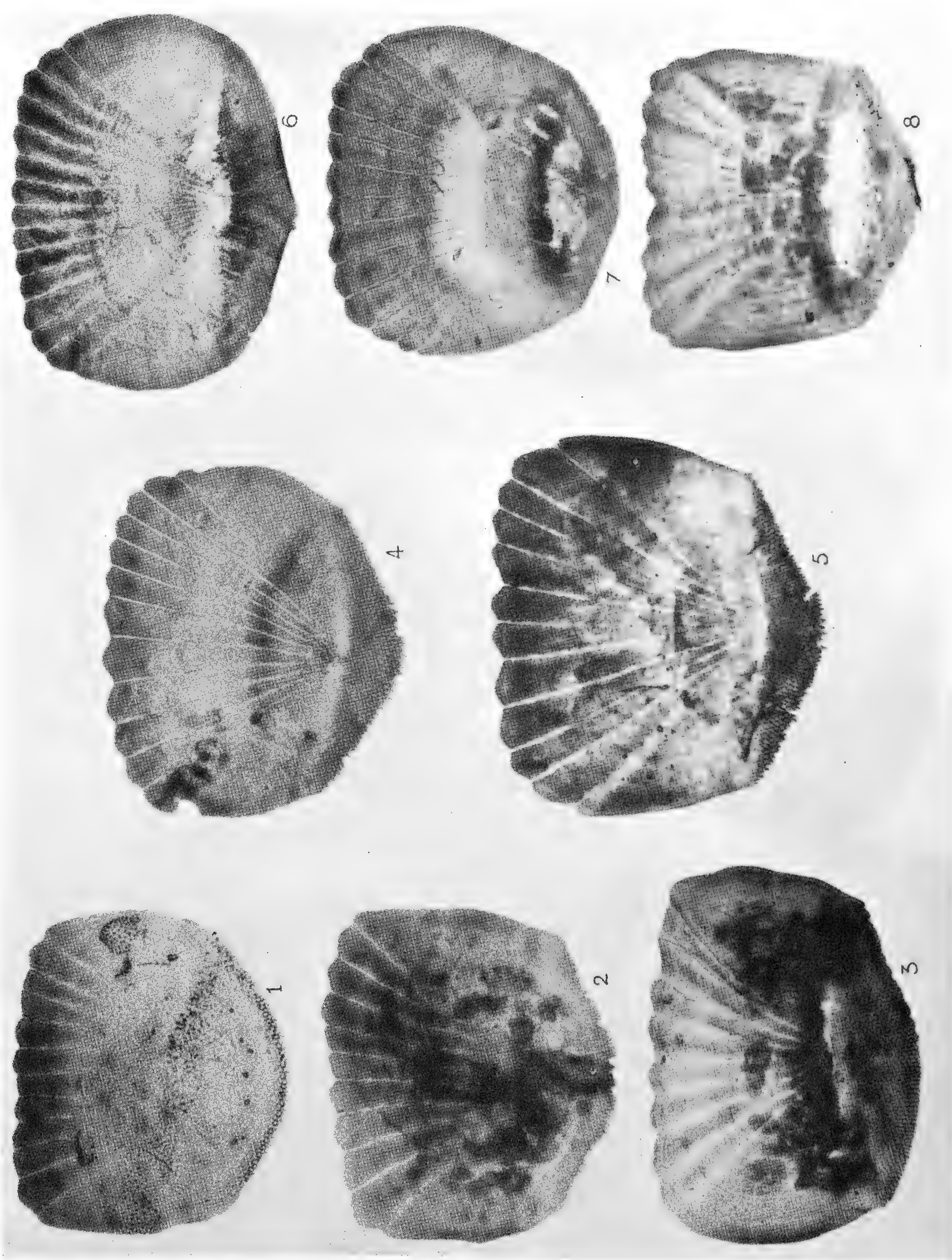
1. *Boopsoidea inornata* Cast., 10th (140). ×21.
2. *Spondyliosoma emarginata* Cuv., 10th (150). ×13.
3. *Pachymetopon blochii* Val., 10th (160). ×20.
4. *Pachymetopon aeneum* G. and T., 10th (350). ×6.
5. *Crenidens crenidens* Forsk., 9th (135). ×13.
6. *Polysteganus coeruleopunctatus* Klunz., 10th (230). ×9.

J. L. B. Smith. *Neill & Co., Ltd.*

Scales of Sparid Fishes.

1. *Austrosparus auriventris* Peters., A. (180). ×8.
2. *Austrosparus auriventris* Peters., B. (180). ×6.
3. *Austrosparus sarba* Forsk., A. (190). ×5.
4. *Sparodon durbanensis* Cast., A. (170). ×8·5.
5. *Sparodon durbanensis* Cast., B. (170). ×6.
6. *Austrosparus globiceps* Cuv., A. (135). ×12.
7. *Austrosparus globiceps* Cuv., B. (135). ×11.
8. *Austrosparus sarba* Forsk., B. (190). ×6.

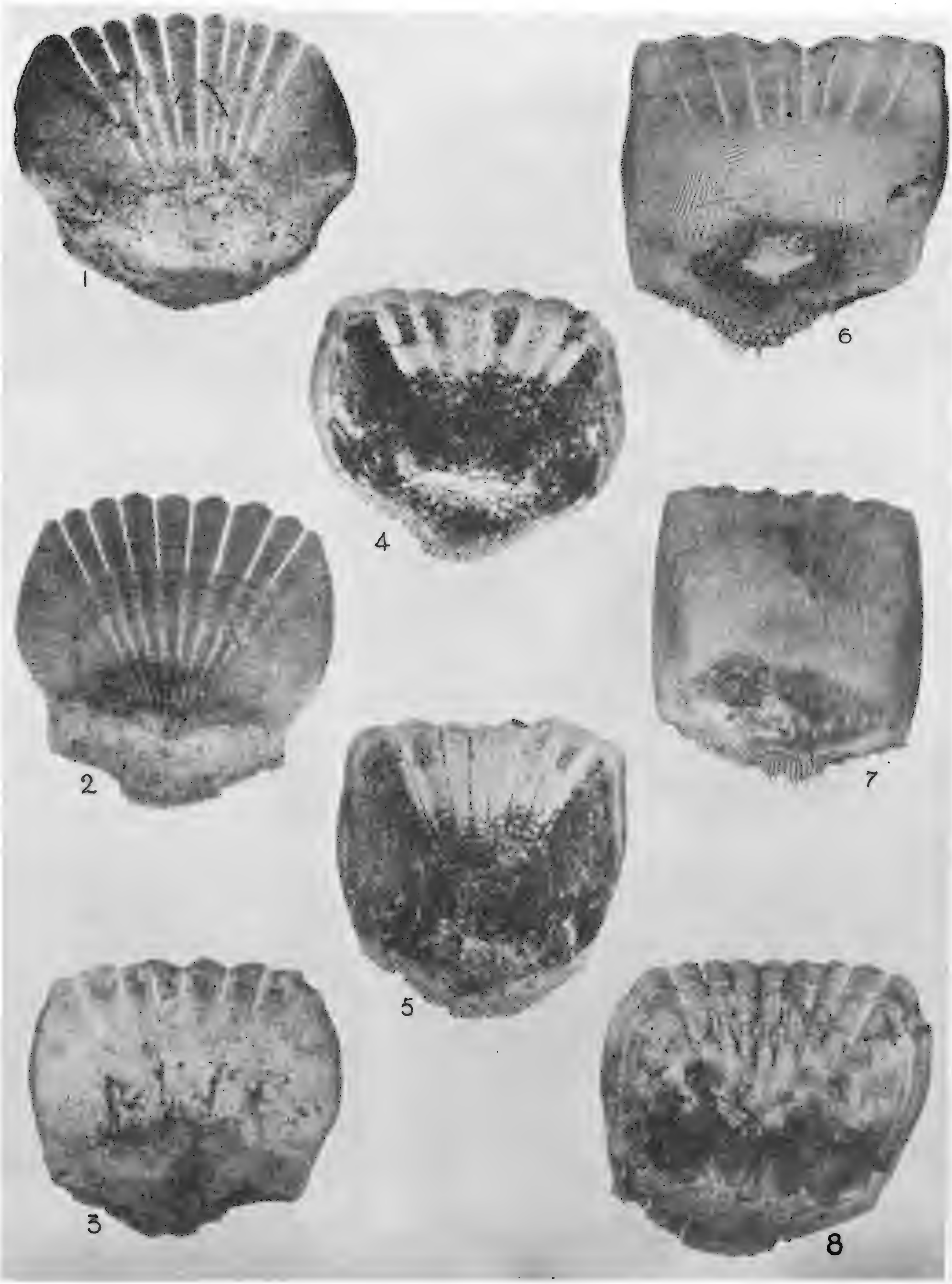
J. L. B. Smith. *Neill & Co., Ltd.*



Scales of Sparid Fishes.

1. *Diplodus sargus* Linn., A. (175). ×12.
2. *Diplodus sargus* Linn., B. (175). ×10.
3. *Chrysoblephus anglicus* G. and T., A. (315). ×8.
4. *Diplodus trifasciatus* Raf., A. (150). ×12.
5. *Diplodus trifasciatus* Raf., B. (150). ×13.
6. *Acanthopagrus bifasciatus* Forsk., A. (165). ×8·5.
7. *Acanthopagrus bifasciatus* Forsk., B. (165). ×7.
8. *Chrysoblephus anglicus* G. and T., B. (315). ×8.

J. L. B. Smith. *Neill & Co., Ltd.*



Scales of Sparid Fishes.

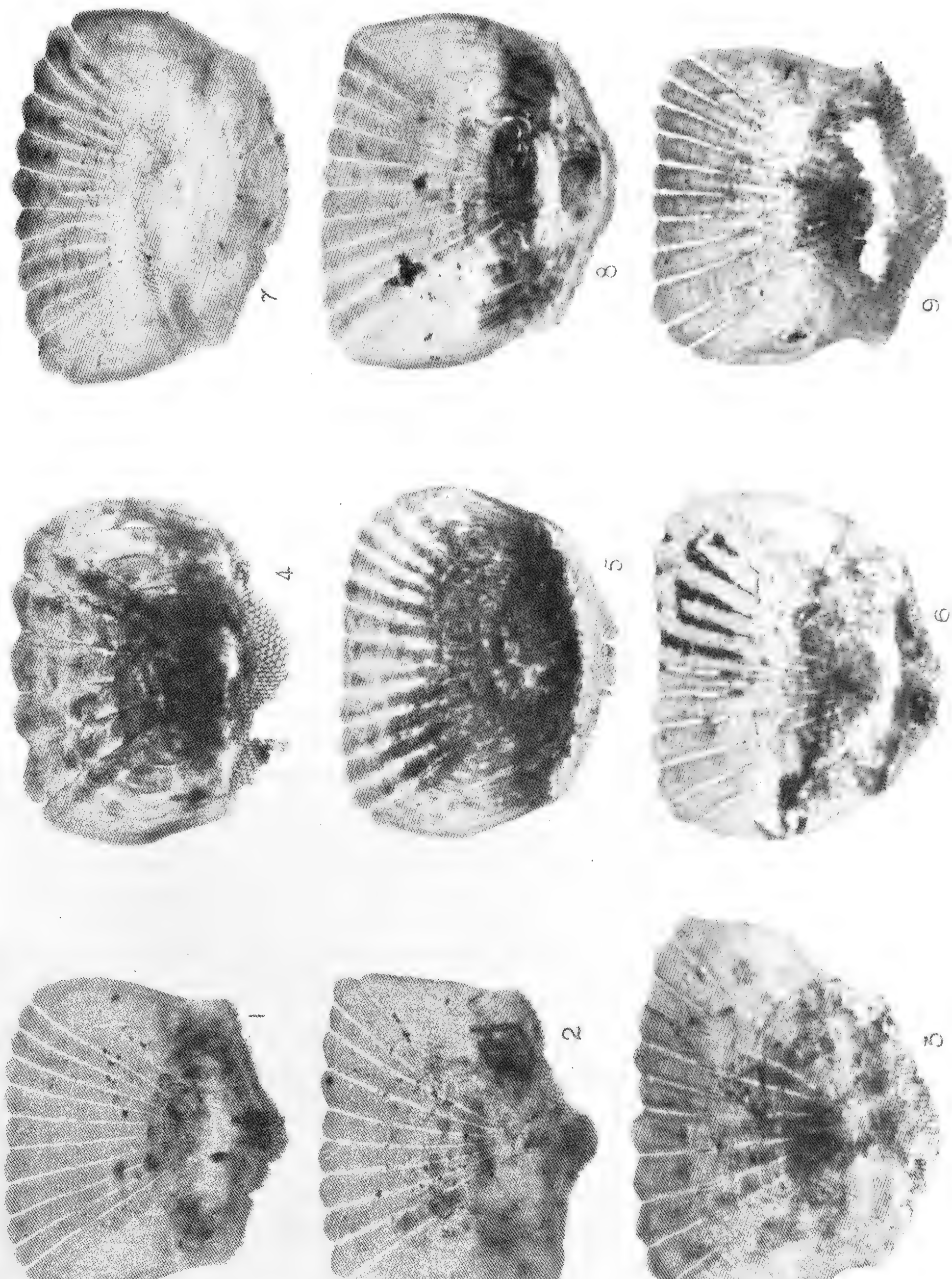
1. *Argyrops spinifer* Forsk., A. (110). ×11.
2. *Argyrops spinifer* Forsk., B. (110). ×12.
3. *Cymatoceps nasutus* Cast., A. (280). ×10.
4. *Pterogymnus laniarius* C. and V., A. (290). ×7.
5. *Pterogymnus laniarius* C. and V., B. (290). ×7.
6. *Porcostoma dentata* G. and T., A. (230). ×18.
7. *Porcostoma dentata* G. and T., B. (230). ×18.
8. *Cymatoceps nasutus* Cast., B. (280). ×7.

J. L. B. Smith. *Neill & Co., Ltd.*

Scales of Denticid Fishes.

1. *Gymnocranius robinsoni* G. and T., A. (300). ×5.
2. *Gymnocranius robinsoni* G. and T., B. (300). ×5.
3. *Cheimerius nufar* C. and V., A. (250). ×7.
4. *Petrus rupestris* C. and V., B. (450). ×5.
5. *Petrus rupestris* C. and V., A. (450). ×9.
6. *Polysteganus argyrozona* C. and V., A. (300). ×8.
7. *Polysteganus argyrozona* C. and V., B. (300). ×6.
8. *Cheimerius nufar* C. and V., B. (250). ×7.

J. L. B. Smith. *Neill & Co., Ltd.*

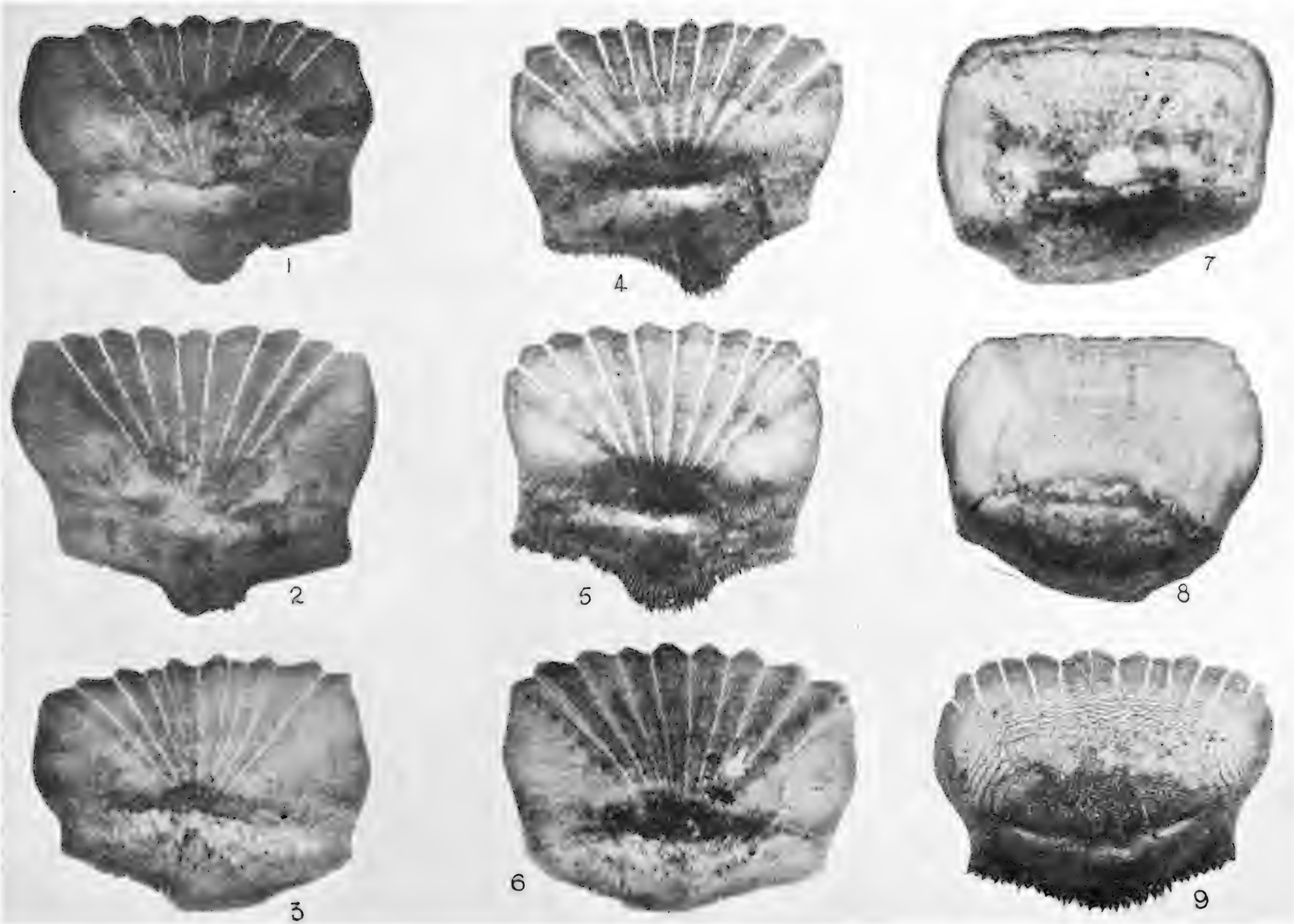


Scales of Sparid and Denticid Fishes.

1. *Polysteganus undulosus* Rgn., A. (200). ×7.
2. *Polysteganus undulosus* Rgn., B. (200). ×12.
3. *Boopsoidea inornata* Cast., A. (140). ×15.
4. *Polysteganus praeorbitalis* Gnthr., A. (300). ×12.
5. *Polysteganus praeorbitalis* Gnthr., B. (300). ×5·5.
6. *Boopsoidea inornata* Cast., B. (140). ×12.
7. *Polysteganus coeruleopunctatus* Klunz., A. (230). ×9.
8. *Polysteganus coeruleopunctatus* Klunz., B. (230). ×6.
9. *Pachmetopon blochii* Val., A. (160). ×15.

J. L. B. Smith.

Neill & Co., Ltd.



Scales of Sparid Fishes.

1. *Pagellus natalensis* Stndr., A. (175). ×12.
2. *Pagellus natalensis* Stndr., B. (175). ×10.
3. *Lithognathus mormyrus* Linn., A. (240). ×9.
4. *Spondyliosoma emarginata* Cuv., A. (150). ×16.
5. *Spondyliosoma emarginata* Cuv., B. (150). ×12.
6. *Lithognathus mormyrus* Linn., B. (240). ×8.
7. *Pachymetopon aeneum* G. and T., A. (350). ×5·5.
8. *Pachymetopon aeneum* G. and T., B. (350). ×4·5.
9. *Pachymetopon blochii* Val., B. (160). ×16.

Transactions of the Royal Society of South Africa. Vol. XXVI.
Part IV. pp. 319–320. November, 1938.

A NEW GOBIOID FISH FROM SOUTH AFRICA.

By J. L. B. SMITH.

(With one Text-figure.)

Family GOBIIDAE.

Gobius keiensis n. sp.

Body rather elongate and slender, tapering gently from shoulder. Snout fairly blunt, upper lip protrudes, some degree of simocephaly.

Depth 5·5, length of head 3·6 in length of body. Eye 5·7, snout 3·2, and postorbital 1·8 in length of head. Interorbital very narrow, eyes almost contiguous. Head 1·7 times as long as deep. Least depth of preorbital equal to vertical diameter of orbit. Eye inserted in first third of head. Front of snout somewhat rugose.

Mouth fairly large, maxilla extends more than an eye diameter behind eye. Lips, especially upper, protrude somewhat. Hind end of maxilla acute, exposed. Teeth villiform, outer series but little enlarged, curved. No canines. Tongue bilobed. Papillae on cheeks very faint, discernible only with difficulty. The rows are mainly almost vertical, with one or two transverse rows running obliquely backwards. The effect is somewhat irregularly reticulate. Gill-openings restricted, membranes fused with isthmus. 8–9 rather small gill-rakers on the lower limb of the anterior arch. No shoulder flaps.

D VI + I 12. First dorsal inserted behind above hind margin of opercle. Spines of first dorsal filamentous, 1st 4, 2nd, longest, 3·5, 3rd 3·7, remainder shorter to the last, 6·7 in length of body. First soft ray 6 in body length, 5th–6th longest, 4·8 in body length, remainder graduated shorter, last ray depressed reaches caudal base. Edge of fin convex. A 1, 12, inserted below the base of the third dorsal ray. Rays slightly shorter than dorsal rays, edge of fin convex.

Pectoral 1·1 in head, reaches to above anal origin. Ventrals 1·3 in head, do not reach vent. Caudal lanceolate, 1·5 times head. Peduncle 1·7 times as long as deep.

Scales strongly ctenoid. Lateral series 30, l. tr. 9 (at shoulder). Head, and nape in advance of dorsal, naked.

Colour.—Olive-grey, lighter below. Several darkish blotches on upper

hind part of body, last at caudal base. Numerous small blotches on scale margins on upper part of body. A dusky patch on the opercle. A dark cruciform patch from below the eye to the maxilla, a smaller fainter oblique bar forwards anteriorly. Dorsal and anal with series of annular darker

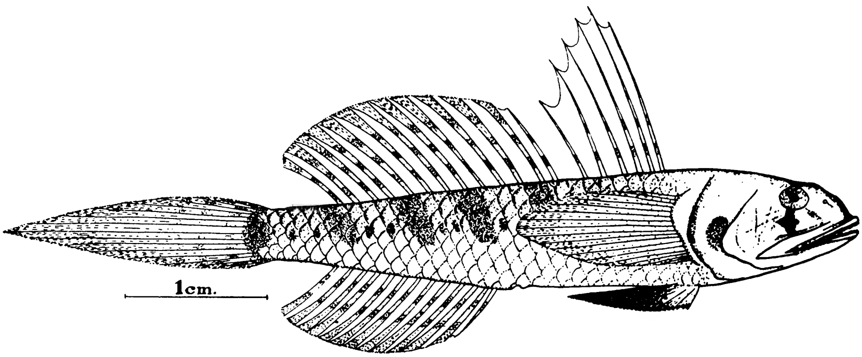


FIG. 1.—*Gobius keiensis* n. sp. (Type).

markings, a few similar on bases of caudal rays. Ventrals mostly dark. Pectorals light. Iris dark, top of head dusky.

Length.—60 mm.

Locality.—Mouth of the Great Kei River.

Type in the Albany Museum, Grahamstown, presented by R. Heathcote, Esq.

This fish might at first sight easily be mistaken for *Gobius acutipennis* C. & V., to which it is related by numerous features. *G. keiensis* is, however, very clearly differentiated by numerous characters. The shape of the head, the very much longer maxilla, the shorter dorsal spines, the shorter ventrals, more slender body, smaller scales and several other features are together more than sufficient to render the species distinct.

The type is a mature female with fully developed ripe ovaries.

I wish to express my gratitude to the Research Grant Board of South Africa (Carnegie Fund) for financial assistance.

ALBANY MUSEUM,
GRAHAMSTOWN,
September 1937.

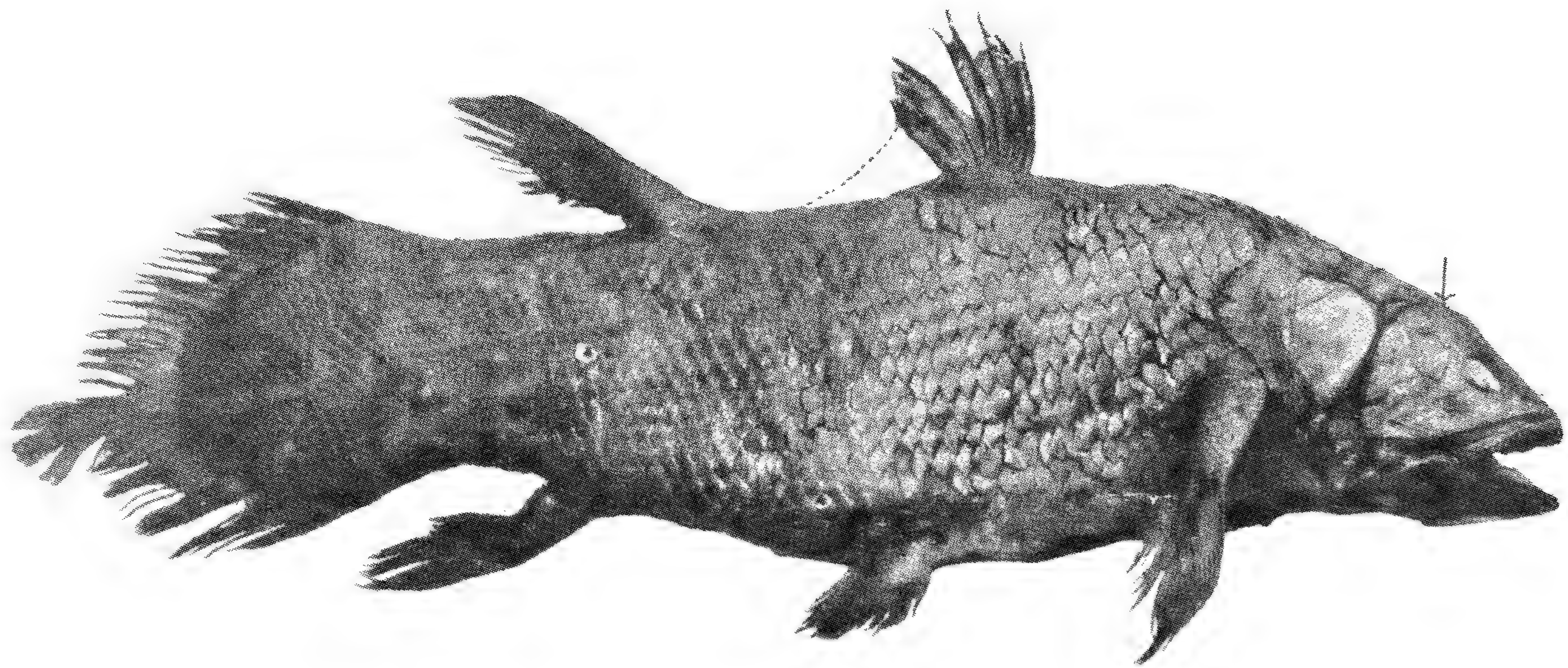
(*Reprinted from* NATURE, *Vol.* 143, *page* 455, *March* 18, 1939.)

A Living Fish of Mesozoic Type

By Dr. J. L. B. Smith, Rhodes University College, Grahamstown

Ex Africa semper aliquid novi. It is my privilege to announce the discovery of a Crossopterygian fish of a type believed to have become extinct by the close of the Mesozoic period. This fish was taken by trawl-net at a depth of about 40 fathoms some miles west of East London on December 22, 1938. It was alive when caught, and shortly after it died it was handed over to Miss Courtenay-Latimer, curator of the East London Museum. Miss Latimer wrote to me, enclosing a sketch and brief particulars of the specimen. Owing to the seasonal disorganization of the postal services, the letter did not reach me at Knysna, some four hundred miles away, until ten days later. It was obvious from the sketch and notes that the fish was of a type believed long extinct. Immediate telephonic communication with the East London Museum revealed that, owing to lack of preserving equipment at that Institution, the putrefied body had been disposed of beyond any hope of redemption, and the fish had been mounted by the local taxidermist.

Since the fish was unquestionably alive when caught, there is at least a possibility that this zoological tragedy may be ameliorated by the capture of another specimen. This is not so remote as might appear. After careful inspection of the mounted specimen, a responsible citizen-angler of East London stated that about five years ago he had found precisely such a fish, only considerably larger (*sic*), partially decomposed, cast up by the waves on a lonely part of the shore east of East London. When he returned with assistance, the monster had vanished with a risen tide. With regard to the present specimen, fortunately both



COELACANTHID FISH FROM EAST LONDON, SOUTH AFRICA.

The small arrow shows the position of the spiracle, and the dotted line indicates the position of a membrane behind the first dorsal fin.

Miss Latimer and the taxidermist were drawn to observe details of the carcass very closely, so that exhaustive independent questioning has left me with at least some definite information about the missing parts. Fortunately also, the terminal caudal portion of the vertebral column and part of the pectoral girdle remain. The skull is of course intact.

The specimen is 1,500 mm. in total length, and weighed 127 lb. when caught. The colour was a bright metallic blue, which has faded to brown with preservation.

In major characters this remarkable specimen shows close relationship with the Mesozoic genus *Macropoma* Agassiz, of the family Cœlacanthidæ, order Actinistia. The gephyrocercal tail with protruding axial supplement, the normal first dorsal, the obtuse lobation of the remaining fins, the ganoin tubercle ornamentation on the scales and on some of the dermal bones of the head, the nature and arrangement of the dentigerous bones of the mouth, and the form of the dermal armour of the head, are all typically cœlacanthid.

The skeleton was cartilaginous, the vertebral column apparently tubular, and the whole fish extraordinarily oily. The fish has small spiracles situated as shown in the accompanying illustration, and a definite though not very obvious lateral line, which continues uninterrupted to the end of the supplementary caudal. Other differences from the known cœlacanthid fishes are the pronounced pedunculation of the lobate pectorals, the reduction of the dermal armour of the head, and the presence of two small heavily ornamented bones at the anterior lower corner of the opercular plate, which probably correspond with the more fully developed inter- and sub-opercula of teleosts, also a similar posterior post-spiracular ossicle. Dermal parafrontals are not visible. There is a free tongue composed of four fused segments covered with presumably ossified tubercles.

It is probable that systematists will wish to propose a new family (some even a new order) for this fish, but I am at present satisfied that it is close enough to the Mesozoic Cœlacanthidæ to

justify its inclusion in that family. It has been noted that certain cœlacanthid fishes underwent little apparent change from the Devonian to the Cretaceous. It is therefore not surprising that this species, which presumably has survived from the Mesozoic, should still retain most of the features which characterize that family.

For the fish described and figured above I propose the name *Latimeria Chalumnæ* gen. et sp. nov.; the full account of the species and of its taxonomic relationships will be published in the *Transactions of the Royal Society of South Africa.*

Transactions of the Royal Society of South Africa. Vol. XXVII.
Part I. pp. 47–50. Pls. III–VII. June, 1939.

A SURVIVING FISH OF THE ORDER ACTINISTIA.

By J. L. B. Smith.

(With Plates III–VII.)

Preliminary Announcement to the Society.

(Read March 15, 1939.)

The various reports and one or two popular articles which have appeared in the daily papers will already have informed members of the Society that an important scientific discovery has recently been made near East London. Since it is my privilege to announce the discovery to the scientific world, it has seemed advisable to issue this preliminary announcement to the Society, to give my opinion of the identity of the specimen, and some authentic details of its structure, since the full description and sufficient figures will take a considerable time to prepare.

The specimen is a Crossopterygian fish of a type believed to have become extinct during the Cretaceous period. Those fishes had for a relatively long period of time been very widely distributed, and palaeontological records indicate that they occurred in vast numbers. From the close of the Mesozoic period to the present day, no trace of living or fossilised Actinistian or Rhipidistian fishes has been found, and all species had been supposed to have become extinct. The fish recently obtained shows that in some remarkable manner one species at least of the order Actinistia has survived, and the discovery opens up all kinds of interesting possibilities.

This fish was taken by a trawler at a depth of about 40 fathoms off the mouth of the Chalumna River, west of East London. It was alive when caught, so vigorous as even to snap viciously at the hand of the captain, and showed signs of life for almost three hours after capture. Shortly after the specimen had died, it was handed over to Miss Courtenay-Latimer, Curator of the East London Museum. Since I generally classify fishes for the Museums in the Eastern Cape area, Miss Latimer wrote to me, enclosing a sketch and brief particulars of the specimen. Owing to some seasonal disorganisation of the postal services, the letter did not reach me at Knysna, some 400 miles away, until 10 days later. Since it was

obvious from the sketch and notes enclosed that the fish was of a type believed to have been long extinct, immediate telephonic contact was established with the East London Museum. This revealed that, owing to lack of suitable preserving equipment and facilities at that Institution, the putrefied carcass had been disposed of beyond the faintest hope of redemption, and the fish had been mounted by the local taxidermist.

In order to stress the extraordinary nature of the discovery, I may inform the Society that even with further information and details supplied by Miss Latimer in reply to my questions, it took a considerable time before I could bring myself to believe what the information apparently represented. When I eventually wrote to Dr. Barnard of the South African Museum to inform him of the find, and to acquaint him with my opinion, it took him also some time to realise that my communication was in earnest. It has indeed come as a shock to the ichthyological world.

Since the fish was unquestionably alive when caught, there is a possibility that the tragic loss of the body may be remedied by the capture of another specimen. It is difficult to account for there having been no previously recorded capture of a specimen of this species. It is possible that it has lived in some region where man seldom penetrates, either at great depths or in some unfrequented stretch of ocean, and that the present specimen is a stray. On the other hand, it may normally live a sluggish life among rocky ledges where trawlers cannot operate and at depths greater than those at which line-fishing is practicable. It appears only remotely possible that the species is not marine. Reports have now been received which indicate that specimens have previously appeared. A reliable citizen-angler of East London has stated that he had some five years previously come across exactly such a fish, only considerably larger, partly decomposed, cast up by the waves on the shore some miles east of East London. He described the specimen in such terms as to render it very likely that he was not mistaken, and stated that when he returned with assistance to fetch the monster, it had disappeared with a risen tide. Also, though probably less reliable than the above, is a statement emanating from some member of the crew of a fishing vessel, that one of them had seen no less than six such fishes taken in one haul near Durban. All had been discarded as unknown vermin.

It may be recorded that both Miss Latimer and the taxidermist had fortunately paid very close attention to details of the carcass during and after skinning. Exhaustive questioning has left me with at least some fairly definite information about the missing parts. Fortunately also, the terminal portion of the vertebral column and part of the pectoral girdle remain. The skull is apparently intact. The mounted specimen is 1500 mm. in length (the fresh specimen was 1400 mm. in length, *fide* Miss

Latimer), and weighed 127 lb. when fresh. The colour was a bright metallic blue, which has faded to brown with preservation. The alimentary canal was entirely empty.

So close is the specimen to the Mesozoic Coelacanthidae (order ACTINISTIA) that it is at present assigned to that family. The gephyrocercal caudal with protruding axial supplement, the normal first dorsal (posterior membrane joined to body), the obtuse lobation of the remaining fins, the ganoin tubercle and/or spine ornamentation on the scales (Pl. V) and on part of the dermal bones of the head, the nature and arrangement of the dentigerous bones of the mouth, absence of maxillae, and the form of the dermal armour of the head, are all typically Coelacanthid. The teeth are mostly conical, the dentition consisting almost entirely of dermal plates which are very obviously merely metamorphosed scales. A lateral line, complete to the end of the supplementary caudal, is present, the lateral line tubes bifurcating posteriorly (Pl. V). The present specimen has spiracles, small but distinct, of such a nature that it is unlikely that they would show in fossilised remains, although it is now easy to place the spiracles in reconstructions since they lie at the lateral ends of the fronto-parietal joint. The dermal armour of the head actually corresponds more closely with that of earlier rather than that of later Coelacanthids. The fins appear to be more pedunculated as compared with those in many of the extinct forms (Pl. VII). There are two small heavily ornamented bones at the anterior lower corner of the opercular plate, which appear to correspond with the inter- and sub-opercula of Teleosts. There is also a similar post-spiracular ossicle. (These three bones may be merely superficial ossifications of the opercular membrane.) Parafrontals are present beneath the skin, the fronto-rostral bones being somewhat stellolaminate, and there is an ossified segmented free "tongue" (dental plate) covered with tubercles resembling those on the scales. The gular plates are large and heavy (Pl. IV).

The Coelacanthid genera appear to be founded on characters which in modern fishes would be regarded as slender. The present species cannot be assigned to any known genus in that family, having indeed features characteristic of several, so as to indicate that a revision of the genera will be necessary. It is, however, beyond dispute that the species is a Coelacanthid, feature by feature the coincidence being most striking. It may occasion surprise that a Mesozoic form could change so little over so relatively vast a period of time as from then till now. It has, however, been noted that certain Coelacanthid fishes underwent little apparent change from the Devonian to the Cretaceous, a considerably longer period.

This specimen shows in the main how close to the truth have been the reconstructions by palaeontologists. Some modifications will be necessary,

chiefly the forms of the reconstructed fins. It has not been realised that the problem of the homologies of the bones of the head has probably been rendered more difficult by the absence of uniform bilateral symmetry. In my specimen on the left side the squamosal is single, whereas on the right it is divided horizontally into two separate bones. Also the "sub-opercle" is missing on the left side.

It was related to me that the flesh of the specimen was of a faint greenish hue, and plastic, almost like soft putty, even when fresh. It was remarked that there was no sign of red blood anywhere about the fish, not even about the gills or vertebral column. The gill-filaments were apparently normal, and of a reddish hue. The gill-arches are stated to have been spinescent, with a few larger recurved hook-like spines on the upper surfaces apparently set in coalesced bases of surrounding smaller denticles, much as the teeth in the jaws. The skeleton was cartilaginous and soft, the vertebral column apparently acentrous, with the notochord presumably persistent. The whole fish was abnormally oily, the skin alone exuding a relatively great amount.

The specimen almost certainly represents a new species, and in so far as I can determine, a new genus also. I have already designated this specimen *Latimeria chalumnae*,* falling in the family Coelacanthidae, and diagnosed in outline by the description given in this paper.

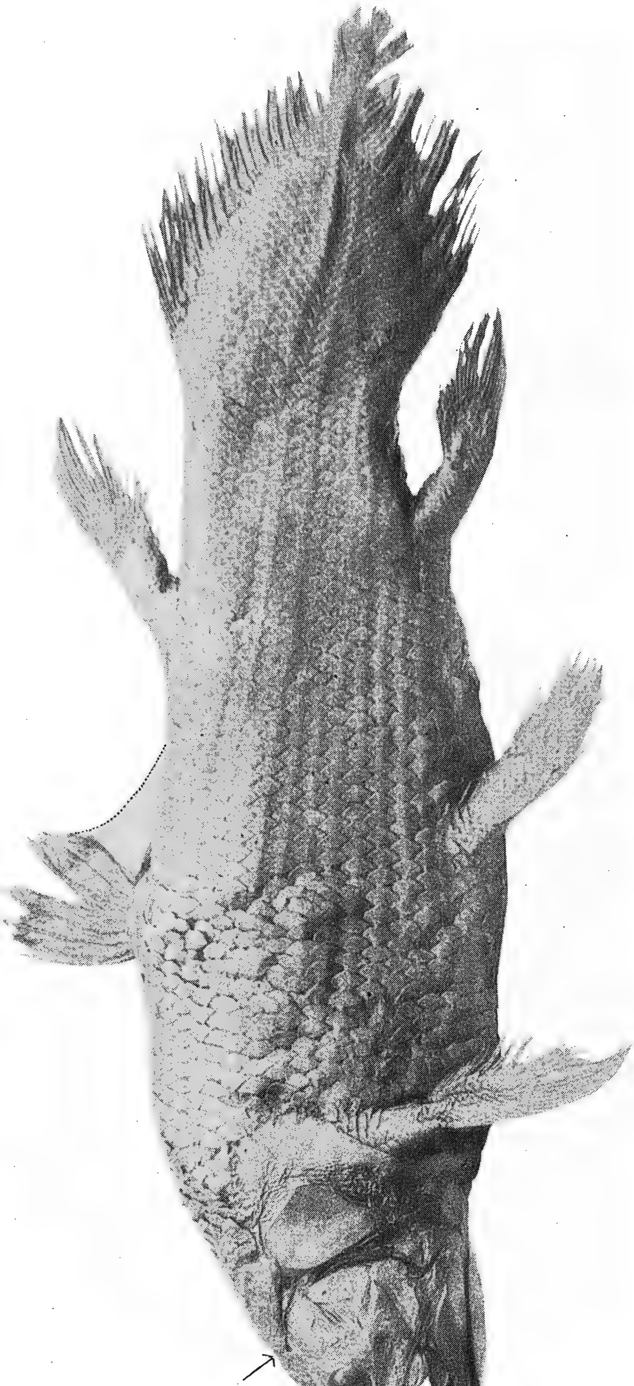
A detailed study of the specimen is in progress, the results of which will be communicated to the Society as early as possible.

With the original of this paper was included only Pl. III. In response to numerous requests, Pls. IV–VII have been added. This is rather unusual in a preliminary paper, but is justified by the extraordinary interest the discovery has aroused.

I wish to express my gratitude to the Research Grant Board for financial assistance (Carnegie Fund), which has defrayed part of the costs of the investigation.

ALBANY MUSEUM,
GRAHAMSTOWN,
March 1939.

* Nature, London, Vol. 143, No. 3620, March 18, 1939, p. 455.



Latimeria chalumnae Smith. $\times \frac{1}{8}$.
The small arrow shows the position of the spiracle.

Latimeria chalumnae Smith. Ventral view. $\times \frac{1}{8}$.

J. L. B. Smith.

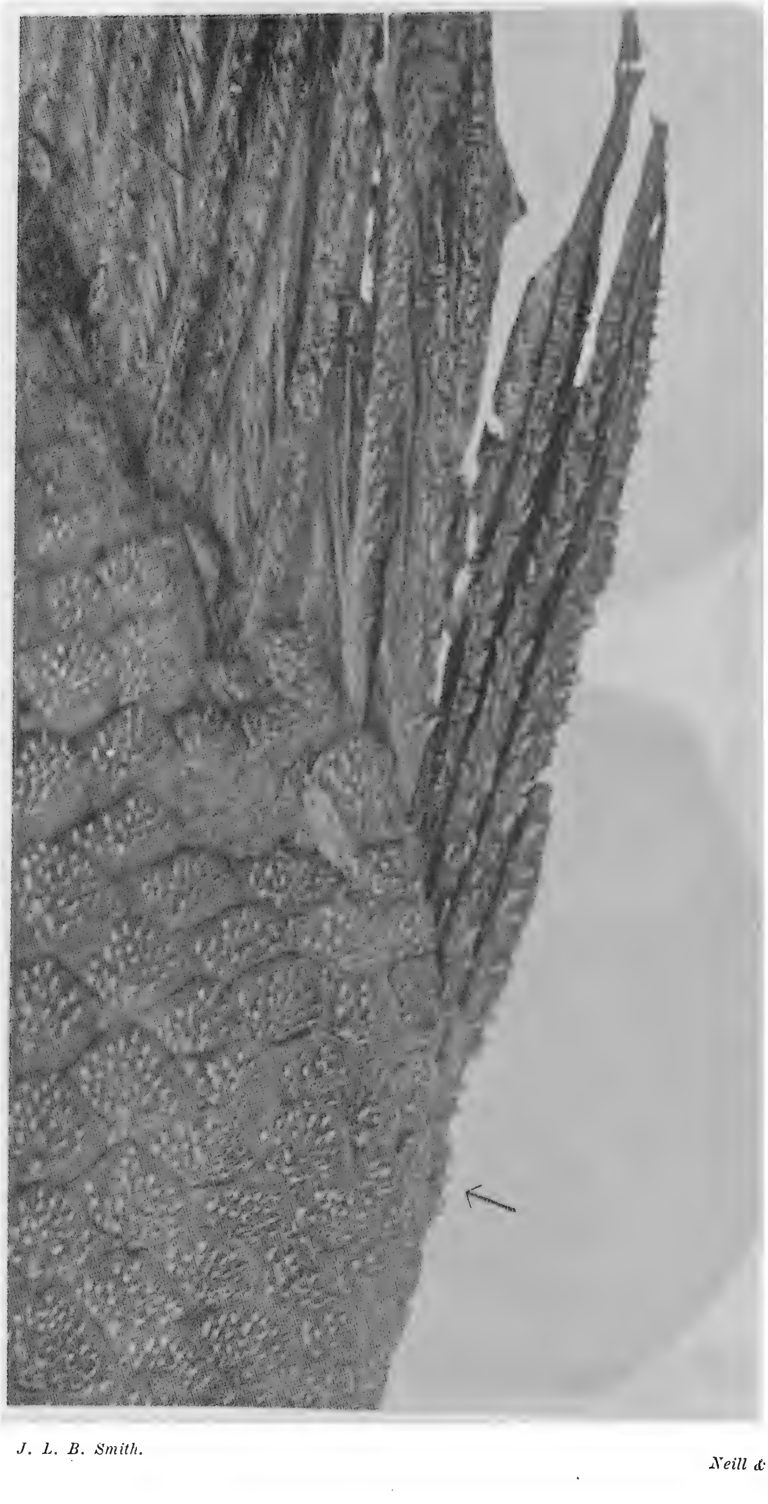
Neill & Co., Ltd.

Latimeria chalumnae Smith. Ninth lateral line scale from left side. × 3.

A. Upper surface showing bifurcated tube.
B. Lower surface showing perforation.

Posterior margin of scale above.

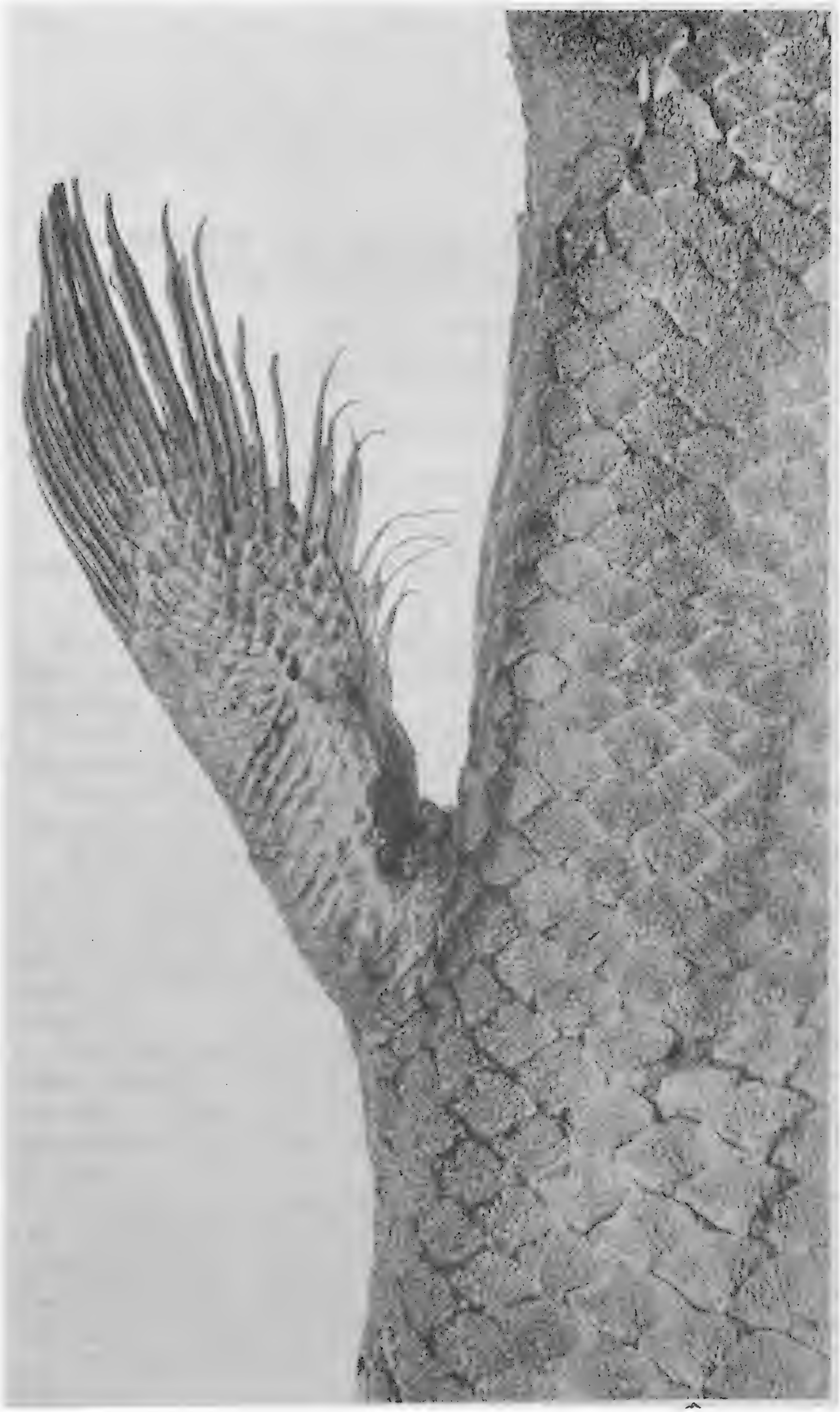
J. L. B. Smith. Neill & Co., Ltd.



Latimeria chalumnae Smith. Anterior principal ventral caudal rays. $\times \frac{1}{5}$, showing some of caudal scaling.
The small arrow shows the first short ray.

J. L. B. Smith.

Neill & Co., Ltd.



Latimeria chalumnae Smith. Second dorsal fin. $\times \frac{1}{2}$, showing some of the scaling. The small arrow shows the lateral line.

395.

Transactions of the Royal Society of South Africa. Vol. XXVII.
Part III. pp. 215–222. December, 1939.

NEW RECORDS AND DESCRIPTIONS OF MARINE FISHES FROM PORTUGUESE EAST AFRICA.

By J. L. B. Smith.

(With two Text-figures.)

(Read March 15, 1939.)

Family MALACANTHIDAE.

Malacanthus latovittatus Lac.

1936. Weber and de Beaufort, Fishes Indo-Austral. Archip., vol. vii, p. 551, fig. 105.

Body elongate, anteriorly subcylindrical, posteriorly compressed. Snout more or less conical, dorsal profile of snout low and evenly convex from nape.

Depth 5·2, length of head 3·55 in length of body. Eye 6·7, snout 2·2, interorbital 3·7, and postorbital part of head 2·5 in length of head.

Posterior nostril slit-like. A strong flat spine on opercle, projecting beyond the hind margin of the operculum. Preopercle not serrate.

Mouth fairly large, almost horizontal, lips fairly thick, jaws subequal, maxilla not to eye, extends below two-thirds of distance from snout tip to eye. Villiform teeth in a narrow band in each jaw, laterally these teeth become more or less conical. Behind these are some smaller granular teeth. No information about gills, gill-rakers and other internal parts available.

D 51, long and low, originates above hind margin of operculum. No sharp definition of anterior spines, though the articulations in the first six rays are rather indefinite. Margin of dorsal gently convex, fin ends just short of caudal base. First ray 6·5, 5th 4·3, mid-rays longest 3·5 in head.

A 42 (or I, 41): inserted below pectoral tip, or the 12th dorsal ray. 1st ray 8·6, 3rd 6·3, anterior mid-rays longest 4·1 in head, thereafter graduated shorter. Edge of fin gently convex, fin ends slightly behind end of dorsal base. Pectoral subfalcate, 1·8 in head, tip reaches above anal origin. Ventrals inserted below pectoral base, 3·0 in head. Caudal

almost truncate, very slightly emarginate, lobes slightly produced. Fins not scaly basally.

Scales small, ctenoid. Lateral line arched from shoulder, drops to middle of side and runs more or less straight on the peduncle. L.l. 132, l.tr. $\frac{10}{47}$, 7 series of scales across cheek. Chin, snout, and interorbital naked, scales on head extend to above hind margin of preopercle, not to eye. Preopercle flange broadly naked. A naked patch above pectoral axil.

Colour (preserved, according to colour sketch made by Senhor Peão Lopes, junior).—Body of a blue shade. From above the eye along the nape tapering to a point halfway along the dorsal base, dark brown. A dark brown longitudinal stripe, wider than eye, running from above the pectoral base to the caudal, continuous on caudal where it widens and bifurcates, the narrower upper and lower arms enclosing a rounded white space about as big as the eye, bordered behind by the hind margin of the caudal. Dorsal brown with white edge. Anal white. A blue-green area on the side of the chest. Operculum greenish. Snout blue. Pectorals and ventrals light.

Length.—373 mm.

Locality.—Coast near Inhambane.

A single specimen, stuffed, in the Museu Alvarez da Castro, Lourenço Marques. This family has not previously been recorded from South Africa. The species described above has been recorded from Mauritius and beyond.

Family LUTIANIDAE.

Glaucosoma peaolopesi n. sp.

(Text-fig. 1.)

Body very compressed, more or less ovate. Dorsal profile of snout steep from nape. Nape prominent, almost gibbous, some degree of simocephaly. Depth 2·1, length of head 3·1 in length of body. Eye 5·0, snout 6·5, interorbital 3·2, and postorbital part of head 2·0 in length of head. Mouth moderate, maxilla expanded posteriorly extends below hind margin of eye. Mouth very oblique, subvertical, lower jaw projects. Supramaxilla apparently present. Teeth in broadish villiform bands in each jaw, the outer enlarged series caniniform. Palatal teeth not visible, probably hidden by mounting. Preopercle margin almost straight, vertical, serrate. A strong flat spine on opercle. No information available about gills and gill-rakers or other internal parts.

D X, 17: inserted in advance of hind opercular margin. Spines short and stout, heteracanth, increase from the first to the fifth, thereafter

subequal. First spine 8, 2nd 5·5, 3rd 4, 5th 3·8 in head. Base of spinous dorsal 2·7 in body. Soft dorsal elevated, anteriorly falcate, rays broad and heavy. First ray 4·4, 2nd 2·8, 3rd and 4th longest, 2·7 in length of body; remaining rays graduated shorter, last one-third of first. Edge of fin gently convex behind anterior rays. Base of soft dorsal 1·2 in base of spinous. Soft dorsal densely scaly at base.

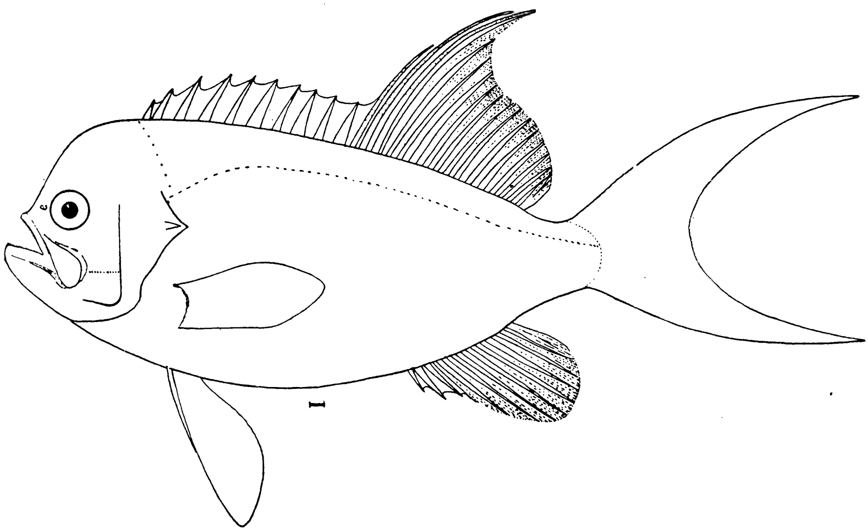


FIG. 1.—*Glaucosoma peaolopesi* n. sp.
The line below the figure represents 1 cm. The dots on preopercle and shoulder indicate number and disposition of scale rows.

A III, 9: inserted below the 6th dorsal ray, spines short and stout, 1st 7, 2nd 4, 3rd 3·6 in length of head. Rays longer than spines, fin gently convex. First ray 2·1, 5th 1·5, and last 2·6 in length of head. Fin densely scaly basally. Pectoral rounded, 1·25 in head. Ventrals inserted below pectoral base, 1·17 in head. Caudal very deeply lunate, lobes almost filamentous. Pectorals, ventrals, and caudal scaly at bases.

Lateral line anteriorly curved, runs parallel with dorsal profile, reaches caudal base well up on dorsal surface of peduncle. Scales ctenoid, rough, covering whole body and head including maxilla and chin. Auxiliary scaling present over most of the body. L.l. 52–53, l.tr. $\frac{9}{25}$, 11 series across cheek (vertical series between hind margin of maxilla and preopercle margin).

Colour (just after death, from notes and sketch made by Senhor A. Peão Lopes).—Pinkish, with yellow suffusion over body. Pectoral, anal, tips of dorsal and all of caudal lobes yellow. Central patch on caudal pink.

Length.—470 mm.

Locality.—On the coast between Delagoa Bay and Inhambane, taken on a line.

Type (a stuffed specimen) in the Museu Alvarez da Castro, Lourenço Marques. Named in honour of Senhor Alberto Peão Lopes of that Museum.

A most interesting specimen, the first species of this genus reported from the African region. The other species are known from the Australian region. In some respects this specimen merits generic distinction from the Australian forms, but that may be left until a complete specimen becomes available.

It may be noted that relatively many Lutianid species are being discovered in our region at the present time. Some, which are plentiful in Delagoa Bay, have only recently been recorded.

Gnathodentex aurolineatus Lac.

1936. Weber and de Beaufort, Fishes Indo-Austral. Archip., vol. vii, p. 348, fig. 72.

Body oblong-ovate, fairly compressed. Dorsal profile of snout but little elevated, gently and evenly convex. Snout sub-conical.

Depth 2·6, length of head 3·0 in length of body. Eye equal to snout, 3·0, interorbital equal to postorbital part of head, 2·7 in length of head. A broad flat triangular spine on opercle, not extending beyond opercular margin. Preopercle margin slightly rough but not denticulate. Posterior nostril circular. Gill-rakers short and stout, 6 on lower limb of anterior arch. Preorbital very shallow, depth 3 in eye.

Mouth moderate, horizontal, maxilla extends to below midway between nostrils and anterior border of eye. Maxilla with a strong externally roughly granulated or serrated bony ridge, the outer face of which remains uncovered by the preorbital even when the mouth is closed. Lips fairly thick. Four fairly large close-set curved caniniform teeth in the front of the upper jaw, a similar smaller one more widely spaced on each side. A prominent outwardly flaring canine on each side in the front of the lower jaw with smaller curved teeth between. A band of villiform teeth in each jaw, narrowing laterally, where those in the outer row are conical and somewhat enlarged. Vomer and palatines edentate.

D X, 10: inserted over hind preopercle margin. Spines fairly slender. First spine 7·3, 2nd 3·3, 4th and 5th subequal, longest, 2·6 in head, remainder graduated very slightly shorter. Soft rays higher than last spine, 1st ray 2·5, 5th longest 1·9 in head. Edge of soft fin strongly convex.

A III, 9: inserted below the base of the 2nd dorsal ray. 1st spine 6, 2nd 3·4 in head, 3rd slightly longer. Soft rays longer than spines, 5th

longest 2·6 in head. Edge of fin convex. Pectoral 1·2 in head. Ventrals 1·5 in head, 1st ray somewhat extended. Caudal moderately forked.

Scales feebly ctenoid, moderate. Lateral line evenly curved from shoulder, follows dorsal profile. L.l. 75, l.tr. $\frac{6}{20}$, 5 series of scales on cheek. Scales on head extend to above hind margin of pupil. Interorbital, snout, chin and preopercle flange naked. Soft dorsal and anal naked, with very low sheath.

Colour.—More or less uniform brown with traces of numerous light longitudinal streaks. Caudal lobes darkish.

Length.—230 mm.

Locality.—Inhaca Island, Delagoa Bay.

This specimen was taken by a net in shallow water. The species is evidently not common, since the fishermen did not recognise it.

This is the first record of this genus and species from South Africa. It has been reported from Mauritius.

Family NEMIPTERIDAE.

Genus *Nemipterus* Swainson.

1933. Fowler (Bull. U.S. Nat. Mus., vol. xii, p. 128) included *filamentosus* Valenciennes in *Dentex* Cuv., and would not accept Swainson's genus founded on *filamentosus*, because Cuvier and Valenciennes' figure (Hist. Nat. Poiss., vol. vi, pl. 155, 1830, *fide* Fowler) shows five rows of scales on the cheek. The general diagnosis of *filamentosus* does not agree with *Dentex*, and Weber and de Beaufort (Fishes Indo-Austral. Archip., 1936, vol. vii, p. 354) record that a recent re-examination of the type of *filamentosus* has shown that it has only three rows of scales on the cheek. Swainson's genus thus becomes valid and has priority over *Synagris* Günther.

Fowler considers *Nemipterus* (=*Synagris* Günther) a Sparid, Weber and de Beaufort a Lutianid genus. It is closer to the latter family, but Regan's classification is followed here, giving family rank to *Nemipterus*, which is fully justified by the characteristic structure of the mouth.

This genus has not previously been recorded from South Africa, though numerous species range through the Indo-Pacific. One species has recently been found in Delagoa Bay.

Nemipterus mulloides n. sp.

(Text-figure 2.)

Body elongate, ovate, compressed. Dorsal profile gently sloping from nape almost uniformly convex, slight prominence before eye. Inter-

orbital convex. Depth 3·4, length of head 3·1 in length of body. Depth of head through preopercle flange equal to length of head less half width of opercle. Eye horizontal diameter 4·0, vertical diameter 4·8, snout 2·6, interorbital 4·0, postorbital part of head 2·6 in length of head. Preorbital smooth, very faintly emarginate over hind end of maxilla. Preorbital with a dense series of parallel subvertical subcutaneous tubules, the posterior branching. (The naked preopercular limb similarly striated.) Least depth of preorbital just more than vertical diameter of eye, slightly

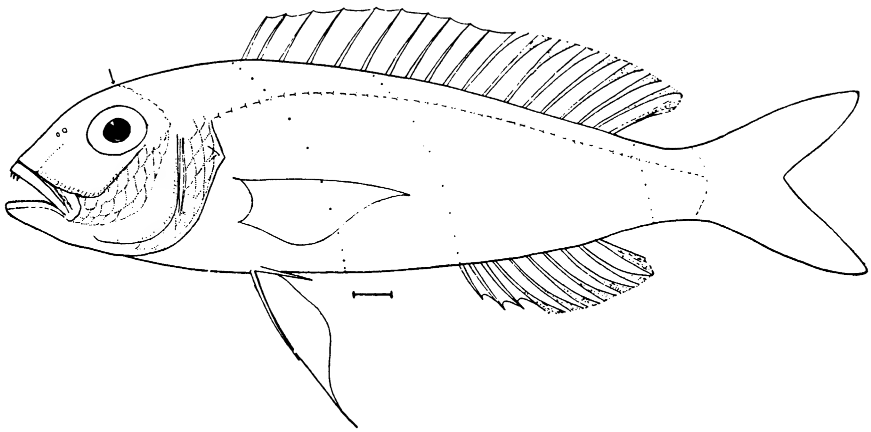


FIG. 2.—*Nemipterus mulloides* n. sp. (Type.)
The line below the figure represents 1 cm. The small arrow shows anterior margin of scaling on head. The rows of dots on the body show number and disposition of scale rows.

less than longitudinal diameter. Hind margin of preorbital when produced cuts dorsal profile half an eye diameter before the origin of the dorsal fin. Nostrils small, circular, close together, at level of centre of eye, slightly nearer anterior margin of eye than snout tip. Preopercle margin quite smooth, naked flange across widest part about as wide as scaly part of cheek. A flat spine, mostly concealed, on the opercle.

Mouth fairly large, slightly oblique, lower jaw shorter than upper, upper canines visible when mouth closed. The maxilla not covered by preorbital, extends to below slightly before anterior margin of eye. Length of maxilla from snout tip 2·6 in length of head. In the upper jaw anteriorly seven enlarged curved caniniform teeth, the outer longest graduated shorter inwards. These upper teeth are at least four times the size of the outer anterior teeth in the lower jaw, which teeth although enlarged could hardly be regarded as canines. Twenty slender sharp curved teeth in the outer lateral series on each side of the upper jaw. Sixteen similar teeth in the outer lateral series on each side of the lower jaw. An inner band of villiform teeth in each jaw, deepest anteriorly.

Gill-membranes separate and free from isthmus. Seven short tubercular spinescent gill-rakers on lower margin of anterior arch. Gill-filaments moderate, longest two-thirds of eye.

D X, 9: inserted behind hind margin of head above pectoral axil. Spinous portion slightly longer than soft. Spines slender, membrane scarcely incised. First spine 4·8, 2nd 4·5, 3rd 4·2, 4th 3·5, 5th to 10th subequal 3·1 in length of head. Soft rays slightly higher than spines, 1st to 8th subequal 2·6 in head, last ray slightly shorter. Edge of fin gently convex. Base of dorsal 1·7 times head.

A III, 7: inserted below first dorsal ray, 1st spine 5·7, 2nd 3·9, 3rd 3·5 in length of head. 1st to 6th rays subequal 2·8 in head, last ray slightly shorter. Base of anal 1·6 in length of head. Pectoral 1·4 in head, equal to distance from snout tip to hind margin of preopercle. Ventral 1·2 in head, first ray filamentous but does not reach anal origin. Ventral axillary scale one-third of fin. Caudal deeply forked; peduncle fairly slender, least depth of peduncle 3 in head.

Scales ctenoid, fairly large; vertically elongate. The second and third series below the lateral line largest, 1·8 times as deep as wide. Lateral line runs almost parallel with dorsal profile, well up on dorsal part of peduncle. Lateral line tubes bifurcate posteriorly into two long branches. L.l. 49, l.tr. $\frac{4}{9}$ from just in advance of dorsal origin. Fifteen predorsal scales, scaling extends above centre of eye. Three series of scales down cheek; there is a fourth series of very narrow scales all but hidden beneath the hind preorbital margin. Three large scales across widest part of opercle. Interorbital, snout, preorbital, chin and preopercle flange naked. Dorsal and anal fins naked; no basal sheath. Caudal densely scaly, inner lobar margins naked.

Colour.—More or less uniform silvery rose, slightly lighter below. A faint opercular blotch, preopercle flange darker. Fins very light yellow, fades on preservation. With preservation there develops an opalescent streak along each scale row below the lateral line.

Length.—215 mm.

Locality.—Delagoa Bay—taken on a line in about 4 fathoms.

Type.—A ripe female, in the Albany Museum.

Several smaller specimens from the same locality, 100–120 mm. in length are doubtfully referred to this species. Positive identification of juveniles in these fishes is exceedingly difficult, indeed the adults do not differ widely between the different species. These juvenile specimens differ chiefly in the depth, which is 3·7–3·9 in body, and in the much shallower preorbital, which is 1·7 in the horizontal diameter of the eye.

N. mulloides belongs to the sub-group in this genus with canines in the upper jaw only, and is related most closely to *mesoprion* Bleeker, which has

been recorded from Singapore and Sumatra. *N. mulloides* differs from *mesoprion* chiefly in the absence of serrations from the preopercle margin, the much broader interorbital, the much longer snout, shorter maxillary, and in the absence of caudal filaments. Also *mesoprion* has a very much narrower naked preopercle margin and more transverse series of scales.

I wish to express my gratitude for the great kindness and assistance received from the Provincial Administration of Mocambique and from the Museum and the Port Authorities at Lourenço Marques during a recent collecting visit. Also to the Research Grant Board of South Africa (Carnegie Fund) for financial assistance.

ALBANY MUSEUM,
GRAHAMSTOWN,
February 1939.

(*Reprinted from* NATURE, *Vol.* 143, *page* 748, *May* 6, 1939.)

The Living Coelacanthid Fish from South Africa

By Dr. J. L. B. Smith, Rhodes University College, Grahamstown

THE recent discovery of the Coelacanthid fish (*Latimeria chalumnæ* J. L. B. Smith) near East London, as described in NATURE of March 18, p. 455, has aroused great interest. This has partly found expression in numerous requests from all parts of the world for the earliest possible publication of a detailed description. I am able to pursue my investigations only in very limited spare time. The preparation of an adequately illustrated detailed description, under present conditions, will occupy several months. I have therefore decided upon the somewhat unusual procedure of issuing a synopsis of the more important results of my investigations to date. This is in the form of brief outlines without discussion.

Few scientific workers are as fortunate as those who have concentrated upon Coelacanthid remains. The present specimen is a living tribute to the accuracy of their interpretations and reconstructions.

The specimen was somewhat damaged in the trawl, the skin having been broken in several places. Repairs were skilfully executed by the taxidermist.

Skull and head. The skull is unfortunately not quite intact. The basisphenoid and part of the structures around the foramen magnum were removed (and discarded) in mounting. The soft parts of the head appear to have been removed rather roughly. The remaining tissues are in poor condition. Only the structures left intact will be described as fact.

Air-bladder. According to the fairly definite evidence of the taxidermist, this organ was at the very most but feebly ossified.

The scales are cycloid and but little ossified. The proportion of residue after ignition of the unornamented portion of a mid-body scale is very much less than, but qualitatively identical with, that obtained by similar treatment of a teleostean scale. The exposed surface of a scale varies from one fourth to one sixth of the total area. The ornamentation on the caudal scales is in the form of spines, on the rest of the body as tubercles. The tubercles are superficial only ; each is set in a thin oval basal plate with corrugated surface. The plates are attached to the scales by tissue which is softened by alkali. The tubercles are of simple structure with a central cavity (see Fig. 1). The lateral line tubes are posteriorly widely bifurcate.

Fins. All the rays of the first dorsal, of the principal and of the supplementary caudal are spinate. A few of the rays of the second dorsal and of the anal are basally feebly spinate. The outer face of the pectoral is spinate. The pelvics only are quite smooth. The bony rays of the dorsal and caudal are articulated. The soft rays are finely articulated to their bases. All rays are composed of two fused lateral segments.

Dermal bones. The cheek-bones are a post-orbital, a squamosal, a preopercular and a sub-orbital (lacrimojugal). On the middle of the lower surface of each cheek is a small bony stud which may be an obsolescent quadratojugal. The opercular is moderate in size. There are two dermal structures in a stage of arrested metamorphosis from scale to dermal bone, which are regarded as subopercular and interopercular respectively.

The intertemporals and the supratemporals appear to be fused. The exposed portion of each frontal is small, oval and flat. These bones are all feebly ornamented. The splenial and angular alone show externally on the lower jaw. The gulars are large and heavy.

Fronto-rostrals. Just beneath the skin there are

nineteen bones in this series on each side. One large frontal and a smaller 'pre'-frontal; nine 'rostro-nasals', including a canal-bearing bone (No. 18) often named 'premaxilla' in fossils.

There are eight bones in the 'parafrontal' series, the anterior expanded bones having been named 'antorbitals' in fossils. Besides these nineteen there are the small dentigerous rostral plates. Most of these bones are small and laminate.

Sensory canals. The main canals run much as have been shown in reconstructions. From the lateral line the canal passes through the supratemporals and intertemporals, thence 'parafrontal'

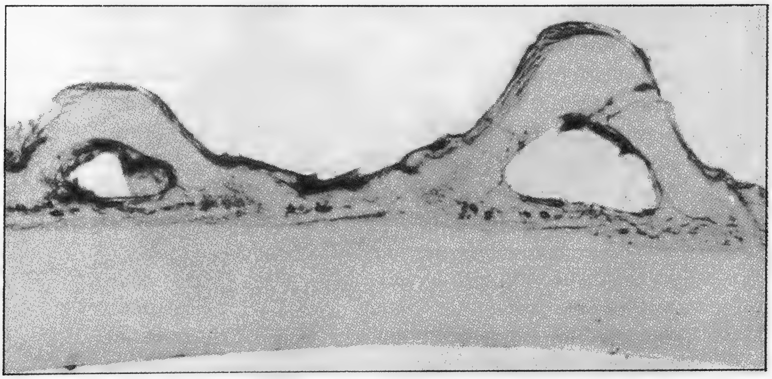


Fig. 1.

SECTION OF A SCALE ($\times 50$) OF *Latimeria chalumnæ* J. L. B. SMITH.

to the snout. There it has a small superior median branch. Just below that it gives off an inferior branch which is the infraorbital canal (running through the lateral limb of bone No. 18, which anastomoses with the suborbital). Below this junction is a commissure across the snout. The canal then runs downwards and curves outwards to end on the outer edge of the rostrum around the inner face of bone No. 18. Just behind the frontal is the junction of the infraorbital canal running downwards through the postorbital, which continues through the suborbital to the snout. The anterior limb of the squamosal anastomoses with the

postorbital-suborbital anastomosis and carries the jugal canal which continues through the preopercular, thence as a tube in the skin obliquely over the lower outer face of the quadrate. It enters the angular very obliquely and thence runs forward on the lower margin just below the surface to the symphysis. There is a posterior branch on the lower surface of the angular.

Olfactory organs. There are on each side three 'narial' apertures, two conventionally on the side of the snout before the eye, the third on the front of the rostrum. Each opening is the end of a simple tube which leads from a median capsule situated beneath a thin layer of mesethmoidal cartilage. The tubes and the capsule were apparently lined with fine rugose tissue. The capsule is depressed biconical in shape. There is also on each side of the rostrum an infero-lateral nasal tentacle, apparently imperforate. On each side of the snout, inferior and anterior to the median nasal cavity, lies a sac, typically covered below, laterally, and partly behind, by the prevomer, in front by bone No. 18. That bone lies against the outer surface of the hind column of the prevomer. These sacs correspond with the usual 'olfactory capsules', but do not appear to have any external narial opening. The nerve supply to these paired capsules appears to be from the olfactory lobe, and to enter at the upper inner portion of the surface. The nerve supply of the mesethmoidal (pineal ?) cavity appears to come from farther back.

Respiratory organs. The branchial arches and appendages were lost. The arches are stated to have been strongly spinate. Remaining is a spinate epihyal and ceratohyal. Also a superficially ossified tuberculate copula ('tongue'), to which appear to have been attached four branchial arches. There is apparently a hyoidean gill-slit behind the free margin of the 'preoperculum'. The spiracles are small and probably functionless.

The palato-pterygo-quadrate apparatus is massive and typically coelacanthid. There is no hyomandi-

bular. The prevomer is an unexpectedly solid structure, with the anterior edge of the auto-palatine bearing against the hind surface of its outer columnar vertical process. The ectopterygoid overlaps the autopalatine and the pterygoid above.

Upper jaw. Maxillæ are absent, probably also premaxillæ. The upper jaw bears paired dermal plates attached to rostrals, prevomers, palatines and ectopterygoids. These plates are of fused small teeth, and each bears one or two large conical tusks. On the pterygoids and parasphenoid

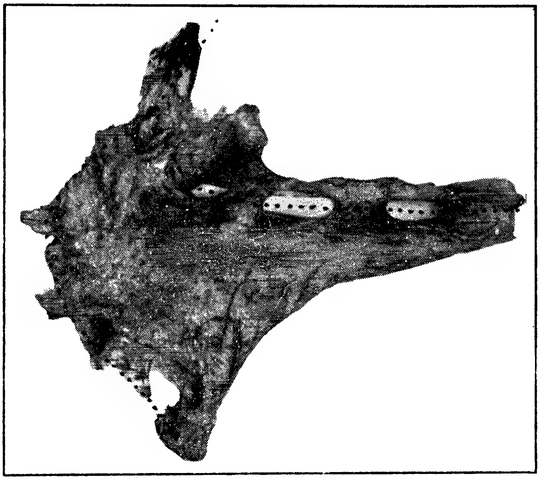


Fig. 2.

ROSTRO-NASAL, NO. 18. NAT. SIZE. INNER MARGIN TO THE LEFT. A PIECE OF WHITE PAPER HAS BEEN INSERTED INTO THE CANAL. THE DOTTED LINES SHOW THE COURSE OF SENSORY CANALS. THE RIGHT-HAND LIMB ANASTOMOSES WITH THE SUBORBITAL

are conical granular teeth. There are two feeble granulate 'epi'-pterygoid areas.

Lower jaw. There is a series of small 'labial' dentate plates on the outer surface of the dentary. Superiorly are four dentate plates on each dentary. The anterior coronoid is small and bears granular teeth as well as several large tusks. The posterior coronoid is large and feebly granulate at the base.

The articular-prearticular plate is very long and is granulate anteriorly only.

Several letters from overseas have contained very harsh criticism about the loss of the carcass of this fish. Few persons outside South Africa have any knowledge of our conditions. In the coastal belt only the South African Museum at Cape Town has a staff of scientific workers among whom is an ichthyologist. The other six small museums serving the coastal area are in extremely poor circumstances, and generally have only a director or curator, who cannot possibly be an expert in all branches of natural history. There are not uncommon fishes in the sea which to any of the latter would appear as strange as, if not stranger than, a coelacanthid. It was the energy and determination of Miss Latimer which saved so much, and scientific workers have good cause to be grateful. The genus *Latimeria* stands as my tribute.

A LIVING FOSSIL[1]

(LATIMERIA CHALUMNAE J. L. B. Smith)

By J. L. B. SMITH
Rhodes University College, Grahamstown, South Africa

[With 3 plates]

Scientific discovery rarely follows a smooth and orderly course. Like most natural processes it proceeds spasmodically, and important results frequently come only after long-drawn-out, exhausting, and apparently fruitless endeavor, sometimes even almost by what appears to be a lucky chance. Scientific discoveries may roughly be divided into two main classes: Those which affect the material welfare of mankind (e. g., the existence and action of bacteria) and those which represent merely an addition to knowledge. There has recently been discovered near East London, South Africa, a very remarkable fish which represents an event of the latter sort. The interest it has aroused is on account of the great scientific importance which attaches to it. It is a living link with a past so remote as to be almost beyond the grasp of the ordinary mind.

In order that the full significance of the discovery may be appreciated, we may recapitulate briefly a few outlines of the theory of evolution. By methods which space does not permit to be explained here, scientists have been able to arrive at an approximate time scale for the comparatively recent part of the history of the earth. According to that scale, life, animal life of sorts, was present in at least some waters of the earth 400 million years ago. We do not know exactly when or where or how that life originated. In the rocks are traces which to experts represent vanished forms. Most of this evidence is in the form of what are known as "fossils." These are the petrified remains of creatures which died in such fashion that their bodies were covered by mud or sand or sludge which to some extent preserved the main structures. At some later date the embedding material was converted by various processes, e. g., pressure, infiltration, etc., into rock. Those records in the rocks are to the paleontologist

[1] Reprinted by permission from The Cape Naturalist, vol. 1, No. 6, July 1939.

something like a book whose leaves can by incredible patience be unfolded. Naturally the oldest records lie in the deepest strata, and those are generally the most distorted and very difficult to read. The record is not complete—there are distressing gaps. In some cases where one class of creature is known to have originated from an ancestral form, no intermediate or "missing link" can be found. The two forms may coexist, and be traced back for a long period in this record in the rocks, showing closer and closer relationship in structure, so as to leave no doubt about the origin of the descendant form. Suddenly in this working back, all signs of the later form cease, and earlier strata will show no traces of it. Thus it sometimes seems as if the new class of creature had suddenly appeared full-fledged and complete. In other cases, however, the developmental or evolutionary record is fortunately complete.

Beyond the disputes of scientists about minor points is the fact that fishes of sorts were the ancestral forms from which all other vertebrate creatures have originated. We have no record of any accepted "link" between these fishes and their most likely invertebrate ancestors. The fishes are suddenly there, some 370 million years ago, in numbers, and in a diversity of weird forms. From the fishes originated the amphibia, and from them the reptiles. These were all cold-blooded creatures, very much at the mercy of sudden climatic changes. The first amphibia appeared about 320 million years ago, and reptiles evolved from them by 90 to 100 million years later. Those sluggish creatures were produced by nature in great diversity of size and shape, but most of the larger forms in specialized groups have become extinct.

The call for greater activity and mobility produced from the reptiles the warm-blooded birds and mammals, the latter class, as typified by man, being now dominant on the earth.

To return to those early fishes, some of which were our ancestors: Many of them, the only ones we know, left traces in the rocks. Usually the skeleton and any teeth, spines, or hard skins are preserved, in rare cases perfectly. The "soft parts" are largely unknown, and the reconstructed outlines of extinct forms are to some extent guesswork, but no more guesswork than the diagnosis of appendicitis by a physician. In each case visualization of the hidden condition is based upon experience and knowledge. How close such visualization may come to actuality may be seen on comparing the outline of a Coelacanthid fish thus reconstructed (fig. 2) with the photograph of the present-day fish. (pl. 1).

The primitive ancestral form of fishes was almost certainly something rather sharklike, without any true bone in its make-up. From those creatures in a relatively brief period of time evolved a multiplicity of types which are generally divided by scientists into four main

groups. These are known as the Placoderms (clumsy "armor-plated fishes"), the Marsipobranchs (jawless sucking-mouthed fishes), the Selachians (fishes with cartilaginous skeletons), and Pisces (fishes with bony skeletons). Many were experimental forms which found competition too severe and so vanished. All of the first group are extinct. They were too clumsy. There are a few miserable remnants of the Marsipobranchs still alive today (hagfish and lampreys). The Selachii are the sharks and rays which have remained vigorous and numerous, and which are one of the great forces in the waters of the earth. In the vast periods of time since their ancestors first spread terror in prehistoric waters, the sharks have changed perhaps less than any other creatures. Many became extinct, but the line was carried on by forms of vigor and activity. Under Pisces are grouped the vast majority of living fishes, and a number who have vanished, some of great significance in the ancestral line.

The immediate importance of this recent discovery lies in the information it affords us about the developmental processes which have led to the typical forms of fishes, and which have been the subject of much research and speculation. This Coelacanthid specimen sheds a great deal of light upon many of those questions, since for some reason parts of this fish are in a condition which may be termed arrested metamorphosis. That is, it bears certain structures which are in process of changing from one thing into another, but the change has not gone to completion. Many of the outer bones of the head in fishes are supposed to have been derived from scales. Also the teeth in the jaws of fishes are believed to be merely scales that have migrated inward and have been changed into tooth-bearing structures. Fins are regarded as having originated from continuous folds of skin developed as stabilizers along the long axis of the body. On these and on many other points the present specimen affords a great deal of important evidence.

The main outline of the evolution of various types belonging to the two chief groups of fishes is shown by the accompanying diagram, which is not to scale. Branches which reach the line 1939 represent groups and forms which have survived to the present day. The others represent extinct forms. The cross-hatched line shows the addition to this scheme necessitated by the recent discovery.

One of the great main branches of the evolutionary tree was the group of the Crossopterygii (or fringe-finned). They were mostly large active predaceous fishes that probably dominated the extensive areas in which they occurred. Like most fishes they originated in fresh water and later migrated to the sea. A large number of forms developed, and were characterized by this peculiar "fringe-finned"

state, and by the heavy bony armature of the head. Many were not very different from the primitive sharklike ancestor, since their inner skeleton consisted at least partly of cartilage or gristle. They were covered by heavy scales, the outer surface of which was ornamented by an enamellike substance known as ganoin. Many of them possessed most peculiar tails, known as gephyrocercal, which are really two tails in one, the extreme tip being a remnant of the original true tail which degenerated. Their pectoral and pelvic fins had developed so as to be very like limbs. It had been supposed that the

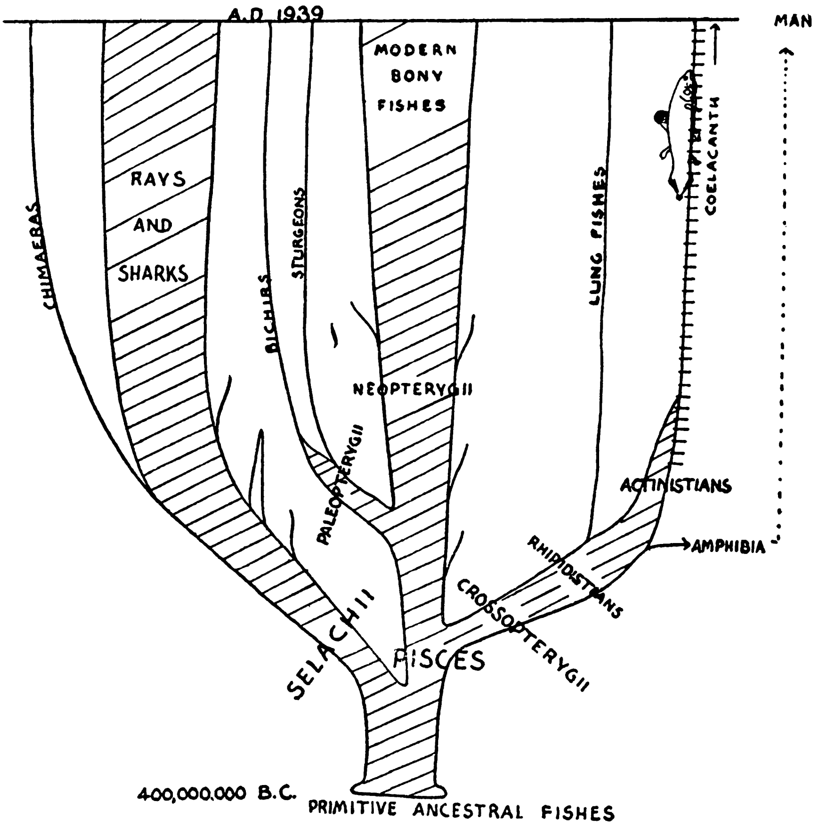


FIGURE 1.—Diagram illustrating the main lines of the evolution of fishes belonging to the groups Selachians and Pisces.

sole living representatives of this ancient line were the few rather scarce species of "lungfishes" living in fresh water in America, Australia, and Africa. They are degenerate forms which are but feeble shadows of their active and predaceous ancestors.

After having lived and flourished for some 250 million years all those other numerous and vigorous Crossopterygian fishes had been supposed to have become extinct by 50 million years ago. The record in the rocks showed how, after having occurred in great num-

bers over a wide area, they diminished, until finally all traces ceased before the end of the Mesozoic era—50 million years ago. Those important fishes had all vanished. Important because they were a link between the early intriguing creatures about whose structure we know so little, and the later vertebrates which have given rise finally to man.

The Crossopterygian stock developed principally through a group known as the Rhipidistians. These flourished from 300 million years ago for about 100 million years. Some of those fishes were the ancestral forms which gave rise, almost simultaneously, to three branches of the evolutionary tree: (*a*) The lungfishes, a thin feeble line that has survived by living an almost isolated life under conditions that scarcely any other creatures can stand; (*b*) Actinistian fishes, the Coelacanthidae, a vigorous branch that flourished for a long period and then just petered out long ago (or was thought to have done so); and (*c*) the amphibia, the origin of all land vertebrates. The two latter groups must have budded off from the parent stock very close together. It is not even unlikely that some of the early Coelacanthids made expeditions ashore along with those unknown amphibian ancestors. If that is so, then for some reason they returned to the water, and extinction, while the amphibian stock multiplied and throve.

Because of their close connection with the origin of land vertebrates, Crossopterygian fishes have been the subject of most intensive researches. In only a few cases have scientists been able to find anything like complete remains. Mostly there are fragments. In almost all cases the bones of the front part of the snout are missing. There have been found very few clues as to structure other than of the hard parts. All very tantalizing, especially as that "missing link" between fishes and amphibians is still missing.

Now, suddenly, there has appeared this great 5-foot fish, bearing the full panoply of his early Mesozoic forbears, but larger than any of them. He is neither puny nor degenerate like the lungfishes, but a great robust animal prepared and fitted to face all the risks in the sea (except a trawl net!). It is as if a fish of 150 million years ago had suddenly come to life. In that incomprehensibly long stretch of time this species has remained virtually unchanged, evidently completely satisfied with itself. In every way this is a true Coelacanthid from that remote past. For at least 150 million years this representative of that ancient but vigorous line has lived in such obscurity as never to have left any known traces of its existence.

The discovery of this Coelacanth is a confirmatory link in the chain of evidence upon which the theory of evolution is based. It stands as a high tribute to the reconstructional ability of scientists

who have had to work chiefly with distorted and fragmentary remains. Although the scientists engaged in such work have been reasonably confident that their reconstructions were fairly close to the truth, there naturally remained a certain element of doubt. It appeared that there could never be any possibility of comparing their efforts with actual specimens, and many people regarded those reconstructions as mere phantasies. This Coelacanth shows that the scientists, in this case at least, have been remarkably accurate in their reconstructions. Even the layman can see how close is the reconstructed form of a Mesozoic Coelacanth to that of the recent fish of East London, South Africa.

Naturally enough this fish will fill in many of the gaps in our knowledge of those earlier forms. What is as important is that the discovery makes it at least possible that there may be other primitive creatures, believed long since extinct, lurking unsuspected in the depths of the ocean. It is more than likely that there is a real "sea-serpent." So many reliable persons have testified independently to having seen that creature (or those creatures) that it cannot all be fabrication. We know almost nothing about what may be present in the depths of the ocean.

I have been asked where this fish is likely to have lived. My opinion—it can be only a guess—is that the species lives among rocky ledges where trawlers cannot operate, and at depths greater than that at which line fishing is practicable. But a number of factors incline me to believe that it does not live at very great depths. Probably 100 to 200 fathoms, along the outer ledges where rocky slopes fade down into the abyss, these Coelacanths lead a "coney-like" existence. Our specimen is probably a stray. There is reliable evidence that others have been seen on our coasts. We hope that the advent of other specimens will be not long delayed. We may even expect other species.

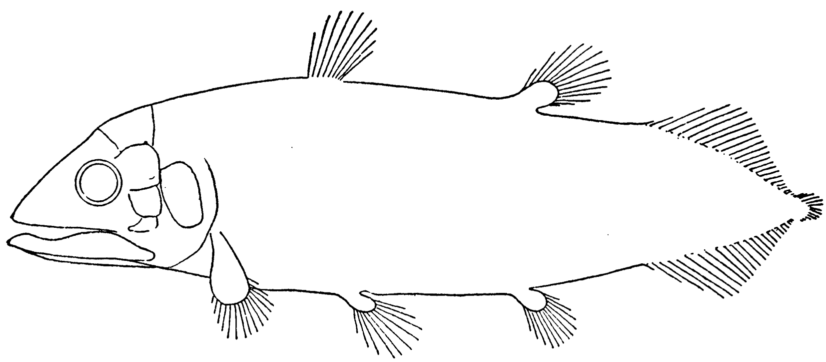
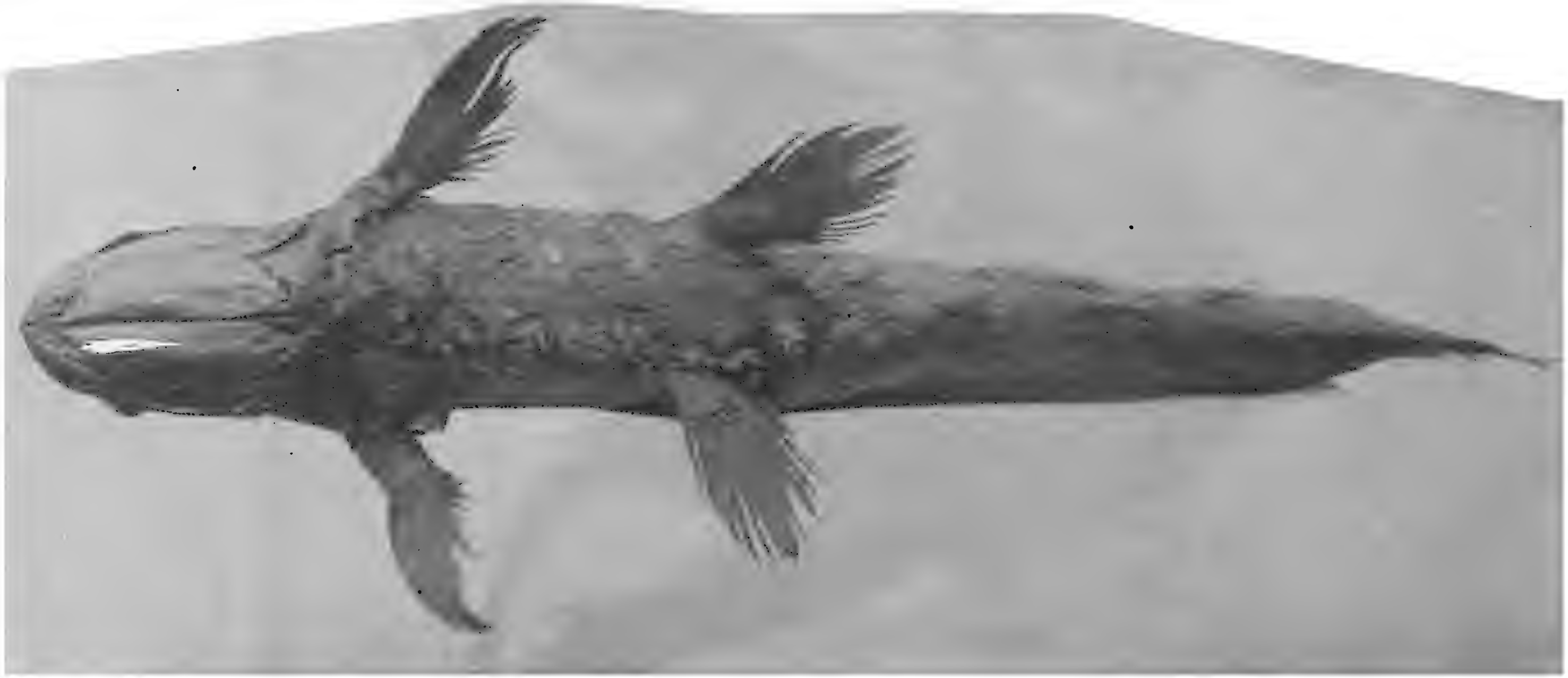


FIGURE 2.—The outline of a Coelacanthid fish, which lived about 150 million years ago as reconstructed from fossil remains.

For those who are interested, the full classification of this fish is as follows: Class: Pisces. Subclass: Crossopterygii. Order: Actinistia. Family: Coelacanthidae. Genus: *Latimeria.* Species: *chalumnae.* The genus and the species are new to science. The genus has been named after Miss Courtenay-Latimer, Curator of the East London Museum, whose energy and enthusiasm have obtained many valuable specimens. *Chalumnae*, the specific name, refers to the locality in which the species was collected, off the mouth of the Chalumna River, some miles west of East London.

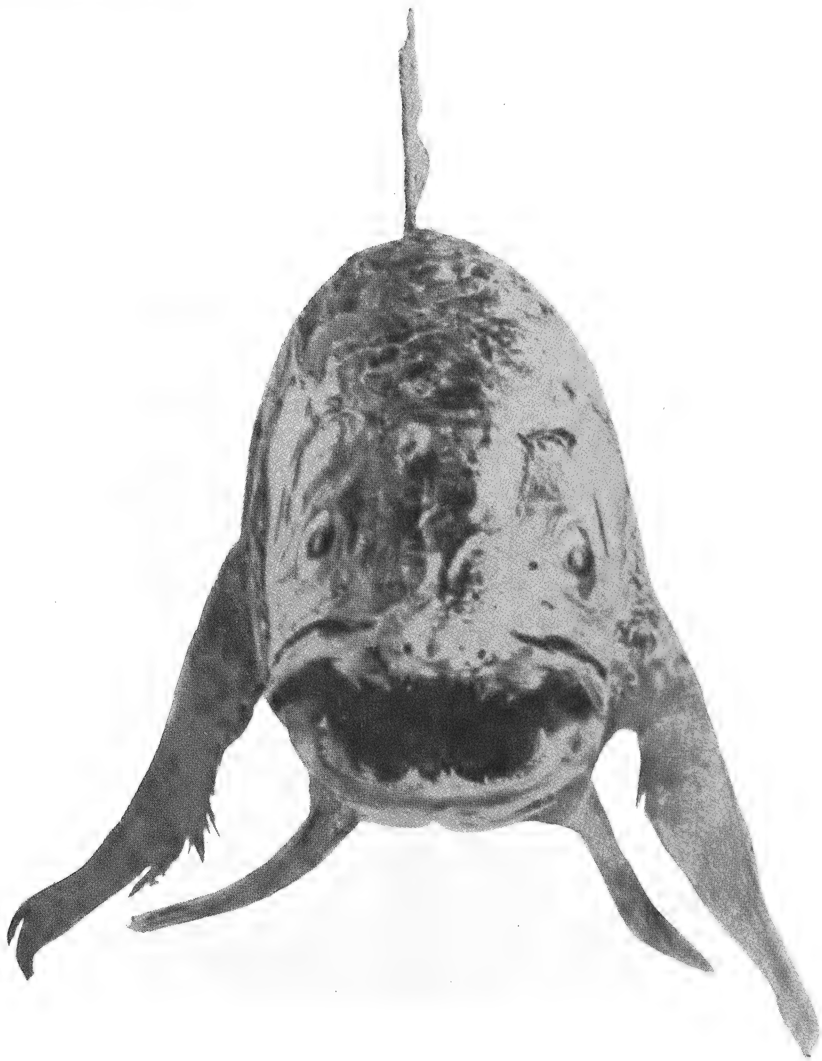
1. LATIMERIA CHALUMNAE J. L. B. SMITH.

The Coelacanthid fish from East London whose discovery is regarded as the most important event in natural history in the twentieth century. This fish, of a type believed to have become extinct in Mesozoic times, was taken by trawlnet at depth of 40 fathoms, some miles west of East London. It was 5 feet long, a bright metallic blue, and weighed 127 pounds. Note the solid fringed fins, very like limbs. The little tufted stump at the hinder end represents the degenerate true tail. The shaded portion replaces a missing part of the dorsal fin.



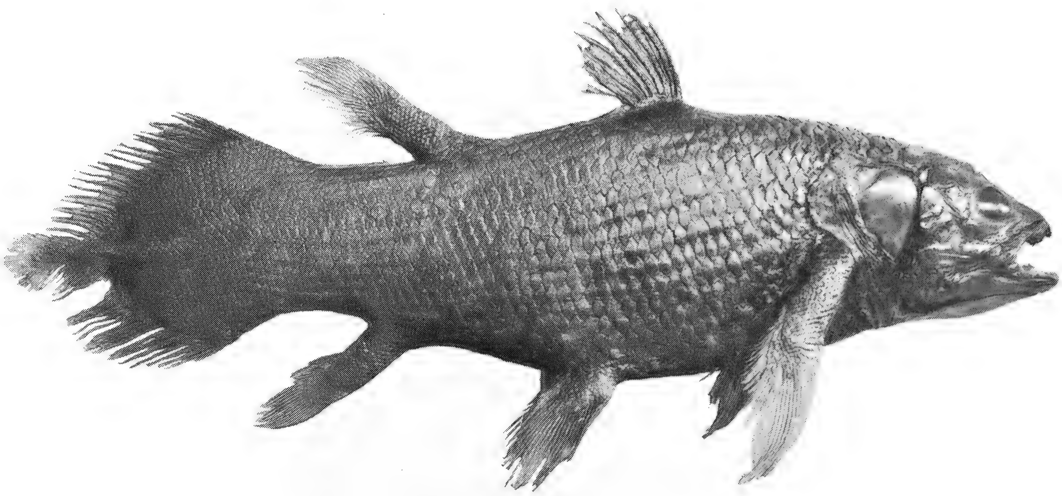
LATIMERIA CHALUMNAE J. L. B. SMITH.

Seen from below. Note reptilian appearance and the two hard plates under the lower jaw. These plates are a regular feature of extinct fishes but absent from modern ones. Much reduced; the fish is 5 feet long.



FACE VIEW OF THE PREHISTORIC FISH FROM EAST LONDON.

COELACANTH
MONOGRAPH



Latimeria chalumnae J. L. B. Smith. Holotype. Total length 1500mm. Photograph by the East London Museum after the specimen had been remounted in 1940.

Transactions of the Royal Society of South Africa. Vol. XXVIII. Part I. pp. 1–106. Pls. I–XLIV. January, 1940.

A LIVING COELACANTHID FISH FROM SOUTH AFRICA.

By J. L. B. Smith.

(With Plates I–XLIV and twenty Text-figures.)

(Read June 21, 1939.)

TABLE OF CONTENTS.

INTRODUCTORY.

For the benefit of the numerous workers who are interested in primitive fishes, and to whom this recently discovered specimen is inaccessible, the preparation of a descriptive account has been pressed forward with as little delay as possible.

This has been accomplished under the chief handicaps of lack of time and of any but relatively crude equipment. Also I have constantly been torn between my desire to give all possible information, and a natural reluctance to dissect or remove structures from so unique a specimen not my own. Further, the task has been rendered the more difficult by the treatment the specimen had undergone. It has been most aggravating to

work with the remains of rudely torn structures, the least of which would have been of inestimable scientific value.

Throughout this work clear distinction is drawn between facts about complete structures and suppositions based upon fragmentary remains or defective parts.

With the chief aim of providing early information, it has been possible to give only the briefest attention to even the more obvious of the many important and interesting sidelights shed by this specimen upon taxonomic problems and upon the nature of fossilised structures. For the same reason it has not been possible to carry out continued polishing of the phrasing of the text, and the text-figures presented are not as finished as they might be, though they are as accurate as repeated observation and measurement can make them. My investigations into the remaining parts of the occipital region have not been so exhaustive as for other structures, since public clamour for view of the specimen curtailed the time it was available to me.

I wish to record here my gratitude to Miss Courtenay-Latimer and to the Board of Trustees of the East London Museum for having entrusted the specimen to my care for over two months, to enable me to carry out my investigations in Grahamstown. This generosity is very greatly appreciated.

An account of the circumstances attending the discovery of the specimen has previously appeared (Smith, Nature, 1939, vol. cxliii, p. 455). It has been explained how a delayed letter was primarily responsible for the tragic loss of the carcass.

To Captain Goosen, who was originally responsible for saving the specimen, I am indebted for most of the details contained in the following description of the conditions attending the catch. The 22nd December 1938 was a normal fine day without high wind. The inshore course of the Mozambique current was normal, *i.e.* from the north-east, more or less parallel with the coast, and of a speed of 1–2 knots at 2–3 miles offshore. Within that belt reverse inshore eddies are sometimes found. The trawl was shot at a point about 3 miles offshore in approximately 37 fathoms, some 18 miles south-west of East London, near the mouth of the Chalumna River. The course was at first north-east for about 3 miles. The vessel then circled around an elliptical area of major axis about 6 and minor about 3½ miles, the long axis set roughly N.W. and S.E., with closest approach to the shore of just less than 2 miles. The centre of this area lies approximately 5 miles offshore, roughly south-west of East London, at 33° 12′ S. and 27° 46′ E. The net was hauled aboard at the close of the ellipse, some 3 miles offshore, in just less than 40 fathoms.

This area is but seldom trawled, since fishes are not commonly found

there. In the trawled area the bottom is composed variably of mud or sand, with pebbly stretches. Immediately to the east of the trawled area is a roughly circular patch of about 2½–3 miles in diameter, of depth 40–46 fathoms, with a bottom of rocky reefs where trawl-nets cannot operate. I hesitate to name this latter as the probable habitat for the Coelacanth, since line-boats frequent that neighbourhood. The area where the catch was made is the inshore portion of a gently inclined shelf 9–11 miles in width, which slopes gradually seawards from 40–60 fathoms of depth. The edge is apparently abrupt, depths of 120 to over 200 fathoms being recorded just beyond the shelf. I have no information about the nature of the bottom at the edge of that shelf, but consider it very probably to be a rocky ridge. Such conditions represent a most likely habitat for the Coelacanth.

When the net had been hauled aboard and the "cod-end" slipped, 3–4 tons of various fishes lay piled on deck. Most of the fishes in any considerable haul are dead by the time they reach the deck of the trawler, certainly those more delicate forms from deeper water. The sorting of the heap in this case took about 30 minutes, and only at the bottom was the Coelacanth observed. It attracted the notice of the captain, who decided to preserve it for the East London Museum. Despite all that it had endured the Coelacanth was alive, and so vigorous as to be aggressive, snapping viciously at nearby hands. It showed signs of life for at least 3 hours after its discovery, *i.e.* 3½–4 hours after removal from the water —a point of significance in connection with its probable habitat.

It is again emphasised that this paper is primarily descriptive, although a certain degree of conjecture and deduction is unavoidable. As far as possible the facts are set forth without relation to zoological polemics, and the nomenclature adopted is in most cases arbitrary. This is particularly the case with the fronto-rostral series of bones. In this fish at any rate it is not easy to define any particular exclusively "frontal" or other neighbouring area where those bones are placed. For that reason most of those ossicles are usually referred to by the numbers assigned in the notation employed.

For convenience and uniformity, throughout all the illustrations each structure is labelled with the same figure or letter. A key to all the symbols employed is given in Folder-page I at the end of the paper.

Family COELACANTHIDAE.

Stensiö, Triassic Fishes, Spitzbergen, 1921, p. 120.

Until a complete specimen becomes available for examination it is hardly advisable to attempt a full revised diagnosis of the family, since

in some respects fossil remains are more complete than the specimen now described. In so far as the features which remain in this specimen are concerned, Stensiö's description (*loc. cit.*) is in the main very accurate, and only brief emendations or additions are given below.

Spiracles present (probably functionless).

No internal narial opening of the mouth. A median rostral sinus with one rostral and two lateral external openings on each side. Olfactory capsules without external openings.

Hyomandibulary system present (of which the opercular is a part), connected with the mandibulary ramus by a "symplectic" bone which articulates with the articular behind the quadrate.

Maxilla and premaxilla absent. Marginal dental plates apparently modified cosmoid scales.

Parafrontal canal continuous with the infraorbital canal and with the rostral commissural canals.

An extracranial cavity within the pterygoidal column (see Spiracular Pouch and Antotic Cavity below), probably corresponding to the primitive condition of the cavum epiptericum of lower Tetrapoda.

The hyomandibulary system suggests affinity with Palaeopterygian forms, *e.g.* Polypteridae and the Chondrostei.

The basicranial structure, with the hinder part of the parasphenoid, had been removed and lost, so that the presence or absence of a myodome cannot be established. From the nature, ~~use~~, and orientation of the size,
remaining structures it appears likely that a structure corresponding to the myodome is present in this fish.

The Coelacanthidae are closely related to the Rhipidistians, and it appears to be generally accepted that the former have originated from the latter. There is as yet no irrefutable evidence on this point, nor any recognised transitional form. The Devonian *Diplocercides* v. Koenen is sometimes cited for this, but both that genus and the related *Nesides* Stensiö are undoubted Coelacanths.

(with the Dipnoi)

It is certainly true that the two groups show marked coincidence in structures not found in other fishes, and records at present show the earliest Rhipidistians to be older than any known Actinistian form. The Coelacanthids are supposed to have originated from the Rhipidistian ancestor partly by loss of the maxillary bones, with consequent modification of the bones of the cheek, also by loss or absorption of several of the more important dermal bones of the head, besides other changes.

There appears to be no satisfactory theory to account for the "loss" of the maxillary bones, nor to explain how such regression occurred. In the living specimen recently discovered the structure of the upper jaw hardly suggests modification due to the "loss" of the maxillary bones,

but rather that those bones were never present, having failed to develop in any ancestral form. The "pseudo-maxillarial" fold (G) found in this fish suggests that the maxilla of fishes originated by modification of some such structure, *i.e.* of a primitive dermal fold, and that in the Coelacanths and their ancestors the necessary modification (and ossification) did not occur. The great development of the coronoids in the lower jaw may be an accompaniment of the non-development of maxillarial bones. The general appearance of the upper jaw and rostrum in this Coelacanth suggests transition from a form with inferior or sub-inferior mouth, in which the pre-oral part of the snout has suffered reduction.

The Coelacanthidae are characterised by immutability in high degree. They are all known to have been very closely related in structure and form, and to have been perhaps the most tenaciously retentive of structure over vast periods of time of all Osteichthyes, possibly of all vertebrates. That particular character is very firmly established by the discovery of a living specimen, which has been found to contain structures practically identical with those of even Devonian forms, and to show more than ordinary correspondence with those of the Permian and the Triassic. The changes which are supposed to have produced the Coelacanth from the Rhipidistian form must have occurred in a relatively brief period of time, since both are there full-fledged, not widely separated in Devonian times. Even allowing that evolutionary changes in those times may have occurred with unusual speed, it seems remarkable that such rapid and relatively profound changes (*i.e.* Rhipidistian to Actinistian) should have ended so abruptly in the relatively immutable, virile, generalised Coelacanthidae.

It is possible that the character of at most slow structural modification has always been typical of the Coelacanthid line, and that those fishes contain structures but little modified from those of even remote ancestors. Possibly the recently discovered aberrant nasal structures may even indicate some affinity with early agnathate vertebrates, which in degree is indicated also by the nature of the upper jaw. That the Coelacanthidae and the Rhipidistians had common ancestry is very probable. That the latter gave rise to the former would appear to require more definite evidence.

Genus *Latimeria* J. L. B. Smith.

Smith, Nature, 1939, vol. cxliii, p. 455 (provisional designation); *ibid.*, vol. cxliii, p. 748.

Smith, Trans. Roy. Soc. S.A., 1939, vol. xxvii, p. 47.

Very large fishes. Body robust, moderately compressed, elongate-oval. Scales cycloid, large, mostly longer than high, with exposed surface sub-rhomboid, surface ornamentation in the form of elongated tubercles or

spines, arranged usually in caudally radiating rows. A single lateral line present, complete to the end of the supplementary caudal. Lateral line tubes bifurcate.

Mouth fairly large, terminal. Maxillae and premaxillae absent. Marginal dentition of upper jaw in the form of dental plates, below rostrals, prevomers, palatines, and ectopterygoids. Dentition primarily raptorial. Teeth all conical, chiefly small, numerous isolated pairs of large tusks. Teeth in dermal plates on lower lips, dentaries, prearticulars, coronoids, rostrals, prevomers, palatines, pterygoids, ectopterygoids, and parasphenoid. Gulars large.

Head large, fairly broad. Prootic large, presumably paired, latero-posteriorly overlapped by and attached to the infero-antrorse process of the supratemporal, over which is bound a capsular process (92). Antotic process and probably also the body of the basisphenoid lightly ossified, cancellate.

A strong, lateral ectethmoidal ossification (38) connecting the palato-quadrate system anteriorly with the parasphenoid and the chondrocranium. The olfactory capsule lies within and anterior to this structure. Parasphenoid large and wide with lateral margins folding dorsally, forming a deep trough bearing the base of the anterior chondrocranium. Brain extending far forwards.

Pterygoid with long, low, anterior limb without notch in its dorsal margin. Autopalatine overlapping the anterior extremity of the pterygoid. Posteriorly the pterygoid has a high lobe, with superiorly the metapterygoid, and inferiorly the quadrate firmly attached to, apparently anchylosed with, the outer face.

Angular long and low, splenial short, both with ganoin-covered exposed portions. Articular short with supero-posterior facet for base of symplectic. Coronoid trapeziform, longer than high, with basal granulate plate. Hyomandibulary system of a symplectic articulating inferiorly at the hind end of the articular, supero-obliquely with a central capsular hyomandibulary ossification bound to the inner anterior face of the opercular. Hyomandibular elongate with lower and upper cartilaginous portions, the upper enveloping the opercular-supratemporal articulation.

Main sensory canals of the head rather wide. Parafrontal canal only not in tubular bone, but carried between bilaminate articulating fronto-rostral and parafrontal series. Preopercular canal continuous in skin of hinder lower cheek with mandibulary canal. A lateral rostro-nasal carrying a canal into which join the parafrontal, the infraorbital, and the rostral commissural canals.

Cheek plates four or five in number, being a postorbital, a suborbital, either a single squamosal or the latter in two parts, as squamosal and suprasquamosal, and a preopercular. Cheek plates articulating posteriorly

to form a "preopercular" system. The four main cheek plates primarily sensory canal bones, circumorbital plates probably absent. Quadratojugal absent or obsolescent. Subopercular and interopercular present but not fully developed. Opercular fairly large, subtriangular, with upper anterior corner articulating with supratemporal. Supratemporal moderate, intertemporal large, joined by moderate suture. Both bones with ganoin-covered areas exposed above the skin. None of the dermal bones much ornamented. The opercular with posterior tubercles.

Extrascapulars four on each side with median connecting unit, reduced to mere tubules or roofing laminae.

Fronto-rostral series of bones lamino-radiate, marginally sutured or articulated, anteriorly with large apertures as pores of the sensory canal system. The main frontal with an infero-posterior process which has the position and function of an alisphenoid.

Gill-openings wide and unrestricted. Opercular membranes of thick wrinkled skin, free from isthmus. Gills 4, spinescent. A tuberculate copula present as a roofing structure to basihyal and to basibranchials. Hyoidean gill-slit probably present. Spiracles present, small, situated laterally below the fronto-intertemporal joint, with lateral groove and posterior ossicle.

Supplementary caudal present. Rays of all fins, except pelvics, partly or fully, weakly or strongly spinescent. Pelvics abdominal, inserted below between the two dorsals. First dorsal short, of 8 robust spiny ossified rays, with posterior membrane. Pectorals, pelvics, anal, and second dorsal fins pedunculate-lobate, scaling far along the lobe. All rays hollow, composed of two lateral segments, and but little expanded distally, finely articulated for almost the entire length.

A central sinus in the mesethmoidal region of the chondrocranium which opens externally through three tubes on each side, one rostral and two antorbital. This organ is not connected with the olfactory capsules, each of which lies within the ectethmoid bone (38) covered anteriorly by the lateral rostro-nasal. The olfactory sacs without external opening. No internal nares in the mouth.

Vertebral column acentrous, notochord persistent, with cartilaginous sheath, to which the neural and haemal arches and spines are probably attached. (No other endoskeletal parts of fins remain.) Extracleithrum present. Supracleithrum a separate ossification.

Air-bladder presumably unossified. (The taxidermist stated that all of the endoskeleton was soft, presumably cartilaginous. I do not consider that can be correct. The few odd portions I have seen, *e.g.* a haemal spine, are only lightly ossified, but they are ossified. The basal plates of the fins were surely well ossified as in other forms.)

Genotype.—*chalumnae* J. L. B. Smith.

Type.—A stuffed specimen in the East London Museum.

I have attempted to prepare a systematic key to the genera of the Coelacanthidae to show the taxonomic relationships of *Latimeria*. With the necessarily incomplete data available it does not appear possible to evolve anything of systematic value.

All the genera are rather closely related. The more primitive show a greater degree of endocranial ossification than those of the Mesozoic, but the remaining known structural differences are generally not of very great taxonomic significance. It is remarkable that all genera and species have the typical form and major characteristics which place the Coelacanthids in a class apart. The present specimen is in every respect a typical member of that family, and shows structural affinities with practically every fossil genus. It is most closely related to those which are recorded from the Carboniferous to the Triassic, and might indeed be placed in several of them. However, it differs from any one by features at least as significant as those which are held to distinguish any two related existing genera.

Originally, when my knowledge of the Coelacanthids was superficially systematic only, I considered *Latimeria* to lie very close to *Macropoma* Agassiz, the only genus of which I then had any detailed account. *Latimeria* is, however, more closely related to the Carboniferous *Rhabdoderma* Reis, and to the Triassic genera *Wimania* Stensiö, *Axelia* Stensiö, *Whiteia* especially Moy-Thomas (and to the imperfectly known *Sassenia* Stensiö, with which *Whiteia* is probably identical). It is possible that *Latimeria* appears to diverge more widely from some of the remaining genera because they are only imperfectly known.

From *Rhabdoderma, Latimeria* is distinguished by the lesser extent of the dermal bones of the head, by the lesser degree of ossification of the endocranium, as well as by the presence of denticles on the lepidotrichia.

From *Whiteia* (known from Greenland and Madagascar), *Latimeria* is distinguished by the nature and extent of the dermal bones of the head, and of the extrascapulars; also by the type of ornament on the scales and head.

From *Wimania, Latimeria* differs chiefly in the type of ornamentation on the scales, in the character of the parafrontal sensory canal, and in the nature and arrangement of the cheek plates.

From *Axelia, Latimeria* is distinguished by the nature of the canal-bearing bones of the cheek, by the dentition, and by the notched dorsal margin of the pterygoid of the former.

Both *Wimania* and *Axelia* have the alisphenoidal-infero-posterior limb to the frontal, which extends behind the fronto-intertemporal joint

to form a junction between the dorsal face of the antotic process of the basisphenoid and the ventral face of the inner lateral margin of the intertemporal (*q.v.*).

What I observe in this specimen of *Latimeria* indicates that the founding of even new species upon variations in fragmentary remains is venturesome. There is not even perfect bilateral symmetry in this one specimen (see Squamosal, and Lateral Line Scales, below). There is likely to be fairly wide variation, especially in external structures, between individuals, certainly among adults, in any one species.

Latimeria chalumnae J. L. B. Smith.

Smith, Nature, 1939, vol. cxliii, p. 455 (provisional designation); *ibid.*, vol. cxliii, p. 748.

Smith, Trans. Roy. Soc. S.A., 1939, vol. xxvii, p. 47.

From what can be ascertained, the body did not suffer any appreciable degree of distortion during mounting, save perhaps slight elongation.

Body elongate, oblong-oval, fairly robust, moderately compressed. The body is thickest at the shoulder and tapers posteriorly very gradually to below the middle of the principal caudal rays, thence rapidly to the supplementary caudal (Plate XIII). The head is not quite as broad as the body. The dorsal profile is almost smooth, fairly gently convex from before the dorsal origin to the snout, with a faint supraorbital prominence at the fronto-intertemporal joint (Plates I, XIV, and XV).

Total length of body to end of supplementary caudal 1500 mm. Depth of body just behind pectoral base, almost uniform to below middle of first dorsal, 370 mm. Depth just behind base of pelvics 345 mm., at origin of second dorsal 295 mm. Width of body behind pectorals 190 mm., in advance of first dorsal 160 mm., just in advance of dorsal principal caudal rays 85 mm.

Length of head in profile from tip of snout to hind margin of opercular membrane 390 mm. Depth of head through anterior margin of opercular plate 250 mm., through hind margin of opercular plate 315 mm. Width of head in profile between upper margins of opercular plates 145 mm. Total width of head across front of opercular plate 168 mm. Maximum width of head across spiracles 155 mm., across centre of eye 150 mm.

Snout in profile 68 mm., measured obliquely 98 mm. Longitudinal diameter of orbit 56 mm., vertical diameter 52 mm. Centre of eye slightly nearer (in profile) snout tip than hind margin of squamosal (24). Centre of eye 2·6 times farther from ventral than from dorsal profile. Hind margin of eye to anterior margin of opercular plate 102 mm., to hind margin of opercular membrane 270 mm.

Interocular space 111 mm. Least depth of suborbital (lacrimo-jugal, 48) 21 mm. Vertical distance between lateral nostrils 16 mm. Lower nostril (B) 8 mm., upper (C) 7 mm. in longitudinal diameter. Upper internarial distance 82 mm., lower internarial distance 99 mm. Distance between rostral narial openings (A) on snout tip 34 mm. Distance from spiracles to snout tip 180 mm. Interspiracular distance 72 mm. Distance from snout tip to the fronto-intertemporal joint 175 mm. Distance from snout tip to hind margin of external pseudo-maxillarial labial fold (G) 145 mm. Total width of mouth at outer margin of pseudo-maxillarial labial fold 180 mm. Width of lower jaw across anterior coronoids (40) 135 mm. Total width of rostrals 55 mm. Total length of mandible 250 mm. Gulars (31) originate 42 mm. behind the tip of the lower jaw at symphysis. Length of gular 225 mm. Maximum width across gulars 132 mm. Distance from snout tip along dorsal profile to origin of scaling on nape 280 mm. Snout tip to first dorsal origin along profile 620 mm., to second dorsal origin 920 mm. Distance from snout tip to anterior margin of pectoral base (in profile) 340 mm., to origin of pelvics 630 mm., to origin of anal 960 mm.

Vent.—The vent appears to have been situated about 80 mm. in advance of the insertion of the anal fin. Unfortunately, the fish had been slit open along the mid-line of the belly, and the repairs render it impossible to decide the exact location of the vent. The taxidermist was unable to assist me in this matter.

There is now no trace of any intromittent organ, nor could any have been present unnoticed. If vivipary in Coelacanths is accepted, this specimen is likely a female. Its size appears to confirm this.

Fins.

(Plates I, II, III, IV, V, VI, VII, VIII, XIII, XIV, XV.)

The paired fins, the second dorsal, and the anal fin are all pedunculate-lobate. They have stout columnar bases, dilating over the point of attachment to the body. Apically they are compressed into a lobe wider than the peduncle, the rays fringing the margin of the lobe. The rays in these lobed fins are rather slender and but little ossified in the exposed parts. They are all only very slightly dilated in the distal portion, if at all. The pelvics only are quite smooth. The rays of the other lobed fins bear some ornamentation in the form of denticles.

The first dorsal and the caudal fins are normal—not lobate. The rays in those fins are, especially anteriorly, heavy and strongly ossified, and heavily armoured with strong spines and tubercles. The degree of ossification and the ornamentation diminish posteriorly and distally. There is some degree of basal scaling for the first dorsal and the caudal fins.

All rays in all fins are articulated. Even in the strongly ossified rays the articulations may be traced far down the structure. The articulations are generally fine and fairly close-set (Plate XXIX).

All rays are composed of two lateral segments, each of which is transversely concave, held together by thin connective tissue. Thus for the greatest part the basal subcylindrical portion of each ray is a hollow cylinder containing cartilaginous tissue. Even the more distal compressed portions have the same structure, though the internal cavity is elongate-oval in cross-section. The membrane connecting the rays is continuous with that binding the ray segments together.

First Dorsal.—First dorsal with 8 rays, practically no scaly basal sheath (Plates I and II), inserted above the end of the first third of the body almost exactly twice as far from the tip of the supplementary caudal as from the tip of the snout. All the rays of the first dorsal are to some extent ossified, though clearly articulated well down into the bony portion. A longitudinal median suture in the first ray shows clearly for the whole length. Dense ossification extends almost the whole length of the first ray, and diminishes progressively posteriorly, the last ray being soft in its distal third. The membrane (now damaged) is thick, and had apparently extended to the tips of the rays with little emargination. Behind the fin the membrane was continued as a flap joined to the back (Plates I and II).

All rays are laterally denticulate, the anterior strongly so. The first ray is very stout, with the basal denticles in several series worn to blunt tubercles. Higher up the ray the denticles are stout but sharp, in two series on each side directed mainly obliquely upwards, and extending to the tip of the ray (extreme tip broken and lost). The second ray (damaged) is slightly less stout than the first, is naked for 15 mm. basally, and bears denticles for almost its entire length. A few of the basal spines are blunted, and for most of its length the ray bears three series of denticles directed at all angles, but chiefly slightly obliquely upwards. The third and fourth rays are of equal thickness, slightly less robust than the second. They are naked for 10 mm. at the base, and the denticles commence irregularly as a single or double series, increasing to two or three rows distally. About nine-tenths of the third ray and about seven-eighths of the fourth ray are strongly ossified, but small denticles continue as a single series on the soft portion. The fifth ray is slightly less ossified distally than the fourth. The denticles are smaller, chiefly directed obliquely upwards, and commence about 15 mm. above the body as a single series of fine points along the distal unossified portion to the tip. Only three-fourths of the sixth ray is strongly ossified, and it is somewhat more slender than the fifth. It bears denticles of form and arrangement similar to those on the fifth ray. The seventh ray is shorter and more slender than the sixth, and densely

ossified for only two-thirds basally. The basal 20 mm. is edentate, and the denticles originate as a single series, becoming double for only a very short distance medially, thereafter continuing as a single series of fine points to the apex. The eighth ray is much the smallest and the most slender. Dense ossification extends for the basal two-thirds, and the denticles are upwardly directed, arranged much as those on the seventh ray, but are much smaller.

Base of dorsal rays 76 mm., total base of first dorsal 230 mm. First dorsal ray (damaged) 128 mm., second (damaged) 135 mm., third 165 mm., fourth 168 mm., fifth 163 mm., sixth 155 mm., seventh 134 mm., and eighth 104 mm. in length.

Second Dorsal.—Second dorsal with 30 rays (Plates I and III) originates above 1·2 times farther from the snout tip than from the end of the supplementary caudal, about midway between the latter point and the middle of the preopercular. The oval base is 62 mm. in transverse diameter (minor axis) and about 105 mm. longitudinally. The fin is directed obliquely backwards, peduncle scarcely bent, at an angle of about 45°. Distance from base to highest margin of scaling 185 mm. Transverse width of peduncle 50 mm., greatest width across scaled lobe 64 mm. Twelfth and thirteenth rays longest, free length beyond scaling 92 mm. Rays fairly slender, only the median (longest), from the ninth to the nineteenth, show a slight degree of distal dilation. The last rays, twenty-fourth to thirtieth, become progressively finer. All the rays are laterally compressed, *i.e.* elongate-oval in cross-section, with fine, close-set articulations the whole free length. The fourteenth to the twenty-first ray inclusive have a few small denticles on the base of the exposed portions in a single series. These are better developed on the right side, but distinct on both.

Anal.—Anal with 29 rays, originates 1·6 times farther from snout tip than from end of supplementary caudal, midway between the latter and the pectoral axil. The oval base is 60 mm. in transverse diameter, about 75 mm. longitudinal diameter. The fin is directed obliquely backwards, lobe bent upwards at an angle to peduncle (Plate I). Distance from body at base to farthest extent of scaling 175 mm. Transverse width of peduncle 50 mm., greatest width across scaled lobe 55 mm.

Twelfth ray longest, free length beyond scaling 92 mm. Rays compressed, fairly slender, little if at all dilated distally. They are more compressed distally, and finely and closely articulated all the free length, in structure exactly as the dorsal rays.

A few basal spinules or tubercles on the mid-rays. Tip of anal lobe reaches to base of third principal ventral caudal ray.

Pectorals.—Pectorals with 32 rays, elongate (Plates I, VII, XIII, XIV,

XV). Peduncle fairly short. Total length from body for right pectoral 330 mm., left 300 mm. Twelfth to fourteenth rays longest, extend 135 mm. beyond scaling. Peduncle 45–55 mm. in width, scaling on flattened lobe 70 mm. wide at widest point. The anterior pectoral rays only moderately compressed basally (beyond scaling), more compressed distally.

From the third to the seventeenth, on the outer surface only, the rays bear a single series of rudimentary spinules or granules which resemble the tubercles on the scales. The lower surface of those rays (*i.e.* against the body) is quite smooth, only one or two slight tubercular irregularities being apparent. The remaining rays are smooth. The tips of the pectorals reach to the base of the pelvics.

Pectorals inserted with upper margin of base slightly below middle of side, and hind margin of base just below the hind margin of the opercular membrane. The front of the base is largely covered by the heavy opercular membrane. The fin is distinctly falcate in outline.

Pelvics.—Pelvics with 33 rays, inserted 1·4 times farther from the tip of the supplementary caudal than from the tip of the snout, immediately behind the base of the last ray of the first dorsal (Plates I, VIII, and XIII). Total length from body 260 mm. (left pelvic), the right is damaged and is sewn closer to the body. Peduncle fairly short and depressed (dorso-ventrally). Longitudinal width of peduncle 65 mm., vertical depth 40 mm. Length from body to apex of scaling on lobe 150 mm., greatest width of scaled lobe 75 mm.

Fin more or less symmetrically fringed, unlike other lobate fins, which are falcate or subfalcate. The fourteenth ray is the longest, free margin beyond scaling 116 mm. Rays moderately compressed at base, apically more strongly, and closely and finely articulated for entire free length. No sign of spinules or granules on rays, which are quite smooth.

Caudal.—Caudal gephyrocercal with protruding axial supplement and very little scaly basal sheath (Plates I, IV, and V). Rays $25 + 38 + 21$. The dorsal principal caudal rays originate slightly in advance of the lower, above 3·2 times farther from the snout tip than from the hind margin of the supplementary caudal, above the 58th lateral line scale.

The caudal peduncle is robust and fairly compressed. Depth of narrowest portion 210 mm., width 105 mm. From the narrowest part the caudal widens, and at the point of origin of the dorsal caudal rays the depth is 235 mm. Across the point of origin of the ventral caudal rays the depth is 250 mm., thereafter the caudal is cuneate and tapers very rapidly to the base of the supplementary caudal (Plates I and IV). In thickness the caudal tapers very gradually, almost imperceptibly, to behind the origin of the principal rays, thereafter very abruptly to the base of the supplementary caudal (Plate XIII).

The 25 dorsal principal caudal rays resemble those of the first dorsal. Anteriorly they are thickened and ossified, decreasingly so posteriorly. All the rays show the median suture observed on the rays of the first dorsal, and are strongly spinose. The first ray is short, 60 mm. free length above scaling, and is completely ossified. It is strongly spinate on the anterior margin and laterally to the tip. The spines are very stout in two main series anteriorly, mostly directed upwards, some almost hook-like. Laterally on each side there is one main irregular series to the tip. Second ray 130 mm. in length beyond basal scaling, only the extreme tip soft, though articulations are visible down into the bony portion. The ray thickens upwards from the base, and is stoutest about the middle of its length. Beyond the tip of the first ray there are on the front of the second ray two rows of upwardly directed stout spinules, one on each side of the median suture, extending to the tip. There are approximately 31 in each row from the tip of the first ray to the apex of the second. Basally the second ray bears two series of similar robust denticles which gradually diminish distally to a single lateral row. The third ray extends beyond the basal scaling about 140 mm., and is soft only at the extreme tip, although, as in the dorsal rays, articulations are visible for a considerable distance down the ray. On this and on the succeeding rays the denticles are confined to the sides. A double series, somewhat irregular, extends from the base to the apex, approximately 37 in each row. The fourth ray is 135 mm. in length beyond the basal scaling, and bears somewhat sharper and more slender upwardly directed denticles which extend to the apex. The fifth and succeeding rays are less robust, and somewhat though comparatively irregularly more widely spaced than the anterior four, whose bases are contiguous. Length of fifth ray beyond basal scaling 130 mm. It bears two lateral series of fairly acute upwardly directed denticles which extend to the apex, as a single series of diminished size on the soft portion of the ray. The sixth ray, 125 mm. beyond the basal scaling, is very similar to the fifth. The seventh to tenth rays are approximately subequal in free length, 115 mm. beyond the basal scaling. They are slightly more slender and apically less ossified than the sixth, each bearing a double series of upwardly directed acute spinules. The eleventh and twelfth rays are similar to the tenth, but slightly shorter, 100 mm. free length. Lateral spinules in two series, apically single. The remaining principal dorsal rays gradually diminish in length, thickness, and degree of ossification. The twentieth ray extends 80 mm. beyond the basal scaling, and is strongly ossified for only the basal third. The articulations are visible right down to the base, and the ray bears an irregular double series of moderate upwardly directed spinules for the basal two-thirds, becoming a single series apically. The remaining five rays are still shorter, the last being

60 mm. in free length. They are soft, and bear chiefly a single row of lateral spinules.

Length of base of dorsal principal caudal rays 300 mm. Margin of fin gently convex, membrane apparently extended to tips of rays in life. First ray approximately 5 mm., fifth 3 mm., and twentieth 2 mm. in thickness.

The 21 ventral principal caudal rays (Plates I, IV, and VI) originate behind the origin of the upper rays, below the 63rd lateral line scale. The rays resemble those of the dorsal portion of the fin, but the spination is more pronounced. The bases of the second to the fifth rays are adjacent. First ray very short and stout, almost like a ventral keel, 22 mm. in length, the free margin being parallel with the body outline. It bears a double series of 9 blunt tubercles. Second ray 55 mm. in length beyond basal scaling, with four rows of upwardly directed stout spines to apex. Third, fourth, and fifth rays are stout, almost completely densely ossified. The third ray has an anterior series of upwardly directed stout spines from beyond the apex of the second ray to the tip, laterally one to two series of similar spines to apex. Fourth and fifth rays with a double to treble series of stout spines laterally. Sixth ray slightly less robust than the preceding rays, but almost fully ossified. Free length beyond basal scaling 108 mm. From the seventh onwards the rays gradually become less robust and progressively less ossified, while the spination diminishes to denticles even smaller than those on the corresponding dorsal caudal rays. Free length of tenth ray 105 mm., of fourteenth 90 mm., of eighteenth 72 mm., and of twenty-first 68 mm. Margin of fin gently convex, membranes extending completely to margin, apparently little if at all emarginate. Base of ventral principal caudal 210 mm. in length.

Externally there is no clear line of demarcation between the principal and the supplementary caudal rays.

Thirty-eight supplementary caudal rays, all soft, very much compressed and flattened, and very finely articulated right down to their bases (Plate V). All the rays are spinate, the spinules basally being fairly prominent in a single series along each ray, becoming progressively smaller apically, but extending to apex, or practically so, in each case. Length of supplementary caudal, including rays, approximately 130 mm. Peduncle much compressed.

Terminal Portion of the Vertebral Column.

The terminal portion of the vertebral column, chiefly of the supplementary caudal, remains. It has been severed 183 mm. in advance of the hind margin of the supplementary caudal rays. Only the extreme end, 28 mm. of the main column, remains. That portion is the end of

a slightly vertically elongated cartilaginous tube about 25 mm. vertical axis and about 20 mm. horizontal axis. The walls are composed of cartilage 2·5–3 mm. in thickness, and at this point they invest the basal portion of the lepidotrichia which run from below upwards at an angle of about 20° to the horizontal. Those from above enter at approximately the same angle.

Behind this apex the vertebral column narrows to a laterally compressed, almost solid cartilaginous structure. It contains a small fibrous core composed of numerous nerve-like threads, which appear to be the caudal prolongation of the notochordal structure. These threads are embedded in soft, spongy tissue, and extend apparently along the axis of the supplementary caudal.

On each side of the cartilage just above the lateral line, the skin appears to be thickened, forming a longitudinal ridge from the supplementary caudal forwards, to above the origin of the ventral principal caudal rays (Plates I, IV, and V). The scales along the apex of this ridge are moulded, being in transverse section very strongly arched, and, like all the caudal scales, bearing rather prominent spinules in irregular series.

The nineteenth principal ventral caudal lepidotrich (Plate XXIX) has been removed. This is 132 mm. in total length, of which 54 mm. is within the body, the inner apical 14 or 15 mm. invested by the substance of the cartilaginous notochordal sheath. This inner extremity of the lepidotrich is almost solid, the internal cavity constricting apically very rapidly to vanishing-point. This internal apex of the lepidotrich tapers gradually to a point, and this pointed apex is by cartilage firmly bound at a slight angle to the severed distal or terminal portion of a haemal "spine." This latter fragment is a lightly ossified, thin-walled, cartilage-filled cylinder, open at the apex, typically "coelacanth." It is merely a feeble perichondral ossification.

In the terminal portion of the vertebral column, at least, the lepidotrichia extend from within the substance of the chordal sheath, and are not articulated with radials as figured in reconstructions.

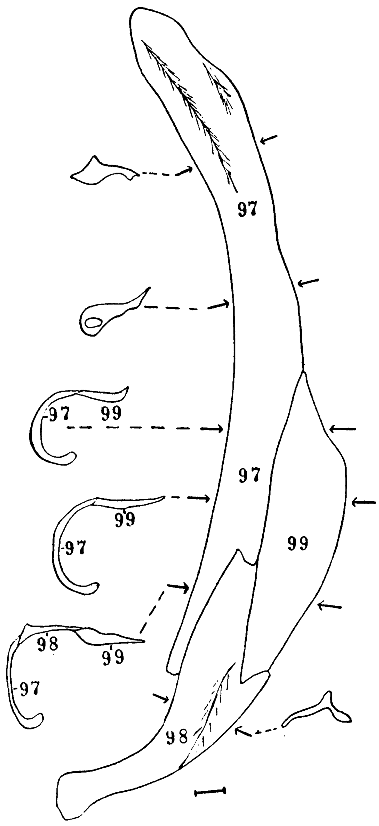
I could not distinguish any definite neural or haemal arch-like structures attached to the remaining portion of the axial sheath.

Pectoral Girdle.

(Plate XXXI; text-figs. 1 and 8.)

The lower part of the pectoral girdle was fortunately not removed by the taxidermist. The remaining structure of the left side has been removed for examination. The whole structure is 270 mm. in length between the two apices. As it lies in the body it has a deep concavity in lateral view

along the major axis. From the apex the upper and lateral surfaces widen so as to be superiorly concave, and to roof over an inverted, downwardly increasing groove. That portion of the structure exposed outside the body appears to bear a coating of enamel, in part with tubercles.



TEXT-FIG. 1.—*Latimeria chalumnae* Smith. Lower unit of left component of shoulder girdle in lateral view. Cross-sections indicated by arrows with upper (lateral) surface of bone above. The line represents 1 cm. Cleithrum (97), clavicle (98), extracleithrum (99).

The clavicular "foot" of each girdle curves inwards and the inner faces articulate below the pharynx, the anterior edge being 205 mm. behind the apex of the lower jaw. The articulation was embedded in cartilage which is continued anteriorly along and above the gular articulation as a median ridge (Z) which becomes lower and smaller anteriorly (text-figs. 8 and 9).

The part of the girdle remaining is a composite, radially ossified structure, with three main ossifications (97, 98, and 99) suturally united. The

under surface of the structure is lined with cartilage to a depth of 4–5 mm. This penetrates to the apex of the fossa in the under part of the cleithrum.

Clavicle (98).

(Plate XXXI; text-figs. 1 and 8.)

The lowest, articulating ossification is the clavicle, of which only a small portion of one flange was exposed outside the body. The clavicle is curved, 115 mm. in length from the lower articulating face to the apex. The hind margin of the convexity lies about 35 mm. from the line joining the apices. The lower extremity of the clavicle has an articulation facet 22 mm. in width (*i.e.* running along the longitudinal axis of the fish), and is flat beneath, the upper surface being somewhat concave with slight ridges on each margin. This "foot" runs outwards and backwards, diminishing in width outwards, the ridges converging and uniting 27 mm. from the facet. This more or less truncated triangular structure forms the articulating "foot" of the clavicular system, which curves inwards from the vertical plane of the shoulder girdle. The bone at this most curved portion of the clavicle is more or less triangular in cross-section, and from 10–11 mm. in thickness. The lateral face of this structure is external, *i.e.* exposed. It curves upwards, dilating apically, and reaches up over the outer curve of the surface of the main structure. In the middle of the outer hinder margin is a deep subvertical angular notch, which lies upon the lower apex of the extracleithrum (99).

From just above the "foot" the clavicle is transversely curved, and hollow beneath, the hollow being filled with cartilage. On the top of the curve, *i.e.* on the exterior surface, is a sharp ridge which defines the exposed portion of the bone. The centre of radiation lies at the origin of the articulating "foot." The exposed surface is strongly ridged and striated with a few low tubercles near the outer trenchant margin. 65 mm. of the inner edge of the upper limb of the clavicle overlaps and articulates with the lower outer edge of the cleithrum (97), the apex of the clavicle fitting into a deep angular notch in that bone. 40 mm. of the outer margin of the clavicle overlaps and articulates with the upper inner margin of the extracleithrum (99). The clavicle thus lies upon both cleithrum (97) and extracleithrum (99), the overlapping being marginally from 2–4 mm. There is no sign of any sense-organ in this bone.

Cleithrum (97).

(Plate XXXI; text-fig. 1.)

The cleithrum is in some respects merely a larger, inverted, reversed edition of the clavicle (98). It has inferiorly a deep angular notch dividing

the lower apically dilated portion into two lobes, the outer much smaller than the inner. The total length of the cleithrum is 115 mm. It is strongly curved, the outer edge of the curvature being 55 mm. from the line joining the apices. From the superior apex the cleithrum is solid and heavy for 110 mm. At 75 mm. from the apex there commences in the under portion of the bone a deep and narrow fossa which at first is completely enclosed within the bone. It then emerges and expands downwards as a deep inverted channel or groove. At first the roof and sides are formed by the cleithrum alone, but at a lower point externally by the extracleithrum (99) also, while at the lowest margin, *i.e.* at the lower extremity of the cleithrum, the inner margin is formed by the cleithrum alone, the roof by the clavicle, the outer margin being clavicle plus extracleithrum.

That portion of the cleithrum which is exposed outside the body is 130 mm. in length, the edge being trenchant. The articulation between cleithrum and extracleithrum extends 70 mm. along the lower outer margin of the cleithrum. The outer lower triangular apex of the cleithrum fits into a notch between the diverging clavicle and extracleithrum.

The upper dense portion of the cleithrum is 22 mm. in width and 9 mm. in thickness at the heaviest part. The under surface is more or less smooth with a slight medio-longitudinal ridge. The upper surface has a sharp high medio-longitudinal ridge which extends almost to the apex, and which vanishes considerably below the origin of the inferior fossa. The exposed outer surface of the cleithrum is superiorly convoluted into ridges and striations. The lower exposed portion is covered with finer radiating striations. On the lower outer margin, concurrent with the upper surface of the extracleithrum, are a number of small rough tubercles.

The centre of radiation of the cleithrum appears to lie on the upper outer margin 70 mm. below the apex. The lowest margin of the cleithrum is fairly abruptly truncated, the width being 23 mm. Progressively inferiorly the cleithrum becomes thinner and more lightly ossified, so that the lowest margin of the truncated portion is scarcely more than cartilage.

There are no sensory organs in this bone.

Extracleithrum (99).

(Plate XXXI; text-fig. 1.)

Following Moy-Thomas and Westoll (Geol. Mag., 1935, vol. lxxii, No. 856, p. 454, fig. 8), the third and entirely external ossification of the shoulder-girdle is designated extracleithrum (99). It lies external to the cleithrum and the clavicle, the inner margin articulating with the outer margins of those bones as well as being overlapped by them. The extracleithrum

is 120 mm. in length, and the maximum width, which occurs about the middle of its length, is 24 mm. It is shaped somewhat like a very obtuse triangle with sides undulant, slightly convex. The upper extremity of the extracleithrum lies 130 mm. from the apex of the cleithrum. The centre of radiation lies just within the outer margin, 42 mm. from the upper apex. From this point forwards and downwards, along the major axis of the lower lobe, runs a thickened portion of the bone which shows both laterally and internally as a ridge, about 8 mm. in width, the total thickness of the bone being 8 mm. The ridge which shows laterally is more or less confluent with the upwardly curving ridge which defines the exposed portion of the clavicle. The internal ridge broadens inferiorly and forms a strong lower apex. The extracleithrum is otherwise more or less laminate, and its surface bears numerous close-set grooves, radiating the full length of the bone in all directions from the radial centre. Along the outer margin of the bone the grooves become somewhat reticulate, and within them and on the ridges lie flat rough tubercles, rather numerous, in irregular series. The outer margin of the extracleithrum is trenchant. The whole surface appears to be covered with enamel. The margin below the cleithrum is serrate for part of its length.

As has previously been indicated, the internal ossifications had been removed by the taxidermist. In so far as I have been able to judge, the fin skeleton was attached to the girdle just inside, certainly not much if at all below, the dorsal apex of the extracleithrum. Most of that bone certainly lies ventral to the point of insertion of the pectoral fin.

There are two parts of this bone which I at first took to be sensory organs. In the cancellate body are two dark oval patches, with a pore above and below. Closer examination has, however, made it almost certain that these are points at which pins (used freely by the taxidermist) had been driven through the bone in securing the opercular membrane to the body. The holes are superimposed and of such a size as to allow a small pin to slip through. The dark patch would be oily matter which has seeped into the bone from the sodden skin.

Supracleithrum.

The supracleithrum is obviously a separate ossification in this fish, and was evidently removed when the fish was mounted. Moy-Thomas and Westoll (Geol. Mag., vol. lxxii, No. 856, October 1935, p. 454, text-fig. 8) have identified an apical ossification, forming an integral part of the cleithrum, as a supracleithrum in *Coelacanthus granulatus* Agas. There is certainly no trace of any such structure in the cleithral element of this fish.

Head External.

(Plates I, IX, X, XI, XII, XIV, and XV.)

The head bears no ordinary scales. The skin is very thick, rather leather-like (Plate XLIV), that of the opercular membrane especially being thick and wrinkled (Plate XXVI). The outer surface of the head consists partly of skin, and partly of the exposed portions of numerous surface bones.

A section of the skin from the cheek is shown in Plate XLIV. In texture it is not unlike the skin of the smaller land vertebrates.

Opercular (28).

(Plates I, X, XIV, XV, XXI, XXVI, and XXVIII;
text-figs. 2, 5, and 13.)

The opercular plates are heavy and solid, and show no sign of cavernous structure. They are only slightly convex above, otherwise the surfaces are plane. The right opercular plate is 123 mm. in height and 90 mm. in maximum width. Practically the whole of the surface of this plate is exposed. Anteriorly it is fairly thick, becoming slightly thinner posteriorly. The anterior margin is broadly bevelled. The lowest point of the bone is the apex of a moderately acute angle. The hind margin is broadly rounded, above and in advance of which is a slight concavity just before the broadly convex highest point of the margin. The surface of the plate bears a few tubercles, a group occurring in the middle of the upper third of the surface. Chiefly they lie in obliquely posterior series in three main groups near the hinder lower margin of the plate, the middle group being the largest. The surface of the plate bears fine straight striae which radiate upwards, backwards, and downwards from a centre near the anterior margin. The surface is covered also with finely reticulate grooves or fine pits. The posterior margins of the plate are on a level with the investing skin.

The left opercular plate is 124 mm. in height and 88 mm. in maximum width. It is very similar in shape and structure to the right plate, but the tubercle ornamentation on the hinder margin is in a large patch, and more extensive than that on the right plate. The greatest thickness of the bone in either plate is 9 mm., and occurs at the upper anterior edge. The hinder margin is about 3 mm. in thickness. (There is a hole in the opercular made by a nail.)

Along the inner anterior margin of the (left) opercular plate is a submarginal ridge, thicker below than above. This is overlaid by the hollow

hyomandibular (94) and its cartilaginous extensions, which extend also 35 mm. below the lower corner of the opercular plate and form an integral part of the thick leathery opercular membrane (text-fig. 12). At the upper inner anterior corner of the opercular, the cartilaginous layer attached to the hyomandibular (94) and the opercular is about 6 mm. in thickness and covers a fairly extensive area, becoming thinner towards the hinder margin. At the upper anterior corner of the opercular beneath the skin is a rounded expansion which articulates with a facet in the lower hinder sub-dermal corner of the supratemporal (50). The lower margin of the supratemporal bears corresponding thick cartilage which envelops the articulation. This articulatory system, which is virtually a hyomandibular suspensorium, is an extremely firm structure.

Subopercular (27).

(Plates XIV, XV, and XX.)

Immediately anterior to and overlapping the lower third of the bevelled anterior margin of the right opercular plate, is a heavily ornamented bone 60 mm. in height and 24 mm. in greatest width (Plate XIV). This bears against the opercular for 40 mm. height, 20 mm. of its hinder lower margin extending below the lowest point of the opercular plate. The exposed portion of this structure has at the apex a very acute angle, with the base approximately 24 mm. in width (Plates XIV and XX). The external surface is densely covered with irregularly radiating series of rounded-elongate tubercles closely resembling those on the anterior body scales. This structure is quite obviously merely a large vertically elongated scale (Plate XX) with the anterior portion invested in the skin partly beneath the preopercular apparatus. This probably represents an arrested metamorphosis from scale to subopercular.

On the left side of the head, which was somewhat damaged, this bone is missing, but the skin pocket which contained it is clearly visible.

Interopercular (26).

(Plates XIV, XV, and XXI; text-fig. 5.)

Anteriorly and inferiorly to the subopercular (27) on the right side lies a small ornamented bone, the ornamented and exposed portion being 19 mm. in height and 11 mm. in maximum width. This might be regarded as a developing interopercular. This proves also to be a modified scale of the opercular membrane. An exactly similar bone occurs on the left side.

Preopercular Flap.

(Plates XIV, XV, and XXI.)

Between the preopercular apparatus and the opercular (28), forming the basis of the connection between them, is a very thick fold of skin which is apically acutely angular (the visible portion). This sweeps down posteriorly parallel with the anterior margin of the opercular, and thence turns backwards to form a posterior, lobate, free, very thick flap strongly reminiscent of the lower preopercular flange in Teleosts.

Anteriorly this skin curves downwards and forwards, thickening to form a free infero-anterior somewhat pointed lobe with apex about 20 mm. above the origin of the mandibular canal (*e*).

In the lower surface of this subtriangular skinny flap are the inter-opercular (26) and the subopercular (27).

Preopercular Apparatus.

(Plates XI, XIV, XV, and XVI; text-fig. 5.)

This consists of a vertical series of several bones, practically contiguous posteriorly, forming an almost straight posterior bony margin which is apparently free. Behind this is a vertical opening in the membrane which is possibly an hyoidean gill-slit (H). Unfortunately, the head was somewhat roughly handled during preservation, so the validity of that slit is doubtful. The general appearance of the present opening and surrounding structures incline me to the view that the species possesses that structure.

Preopercular (25).

(Plates XI, XIV, XV, and XVI; text-figs. 5 and 17.)

The lowest bone of the preopercular series is identified as the pre-opercular. It forms the lower angle of the preoperculum or cheek system, and in shape suggests a small hatchet with broad tapering handle, the long axis being horizontal. The surface of the bone is almost plane. The right preopercular is 78 mm. in length and its greatest height is 35 mm. The surface is excavated into pits and channels, and most of the bone is of cavernous and light structure. On the middle of the horizontal limb are a few smooth rounded tubercles set in depressions. Practically the whole of the upper surface of the bone is exposed.

The left preopercular has been removed and freed from skin. It is similar in form and ornamentation to that of the right. Its horizontal length is 75 mm. and the vertical height is 37 mm. Only a small bevelled

flange is covered by skin. The horizontal limb is laminate and fairly solid. The vertical limb is cavernous and porous. The main sensory canal runs straight through the bone from the upper inner angle, the inferior opening being at the lower margin of the origin of the horizontal limb. Several side branches run from the main channel to the vertical hind edge of the limb (text-fig. 5). The centre of radiation is at the middle of the canal, just within the inner (anterior) angle.

Squamosal (24).

(Plates XI, XIV, XV, and XVI; text-figs. 5 and 17.)

The preopercular apparatus is not symmetrical. On the left side the squamosal consists of a single bone which has been removed and freed from the skin (Plate XVI). The hind margin of this bone is very slightly concave, the lower hinder corner being somewhat pointed. The main body of the squamosal is elongate, roughly oval. On the lower third of the inner (anterior) margin is a slightly oblique, acutely angular, but apically truncated projection, which is mostly covered by the skin, the subcutaneous portion projecting forward to meet the hind upper margin of the lacrimo-jugal (48) and the lower projection of the postorbital plate (23). The upper margin of the squamosal rests against the outer lower bevelled margin of the postorbital. Height of left squamosal 66 mm., greatest width of main plate 31 mm. Total width exposed 44 mm.

The upper portion of the squamosal is practically solid, with transverse section triangular with very acute apex, the hind margin being very sharp, the anterior margin being approximately 3 mm. in thickness and broadly bevelled, the bevelling all subcutaneous. The upper margin of the bevelling is produced into two sharp points which slip below the margin of the postorbital element. The forwardly directed triangular projection is little else than a bony tube bearing the jugal canal, with posterior terminal opening on the lower margin below about the middle of the main plate. This canal also communicates superiorly and inferiorly with numerous marginal openings (text-fig. 5). The lower portion of the squamosal (*i.e.* on the main plate), where it is a projection from the tubular section, is very light and cavernous.

The upper half of the surface of the squamosal bears a more or less reticulate system of shallow pits and canals. A few scattered nodules or tubercles are present round the margin of this portion. The lower portion of this surface bears a number of deep excavations roofed by a thin membrane, which communicate with the main jugal canal (*d*). Between those the surface is pitted and striated in the same fashion as the upper portion of the bone, with only two small tubercles visible. (The plate shows a

deep excavation on the upper surface of this bone. That was made by a nail used by the taxidermist.)

On the right side the squamosal is in two parts, but there is no sign of a corresponding suture in the left squamosal. The two halves appear to be widely bevelled over the line of division, and the upper portion is much thinner than the corresponding part of the left squamosal. The upper portion is solid, apparently not at all porous (the two holes which show in the plate were caused by nails). The upper portion of the right squamosal which shows above the skin is broadly triangular, with the base subvertical posteriorly, and the apex round and blunted. Height of base 53 mm., base to apex 32 mm. The surface is covered with shallow, more or less reticulate ridges. Near the hind margin is a vertically elongated group of about a dozen widely separated small tubercles, and there are several near the upper anterior margin also. The lower portion of the bone is obviously very porous, and bears the jugal canal. It is irregularly very acutely triangular in shape, with the lower margin almost sigmoid. The hinder part of the surface bears numerous deep excavations which communicate with the jugal canal. The remainder of the surface is covered with reticulate ridges similar to those found on the upper bone. There are several small tubercles on the upper hinder angle of the bone. The squamosals have an almost plane surface, with very slight lower convexity. The centre of radiation of the left squamosal lies on the canal, just within the inner (anterior) angle.

Postorbital (23).

(Plates X, XI, XII, XIV, XV, XVI, and XVII; text-figs. 5 and 17.)

The postorbital element consists of a single bone whose surface is curved more or less uniformly from the central highest area. The left postorbital has been removed and freed from skin. Its total height is 85 mm., 95 mm. along the profile of the curve. The surface of the bone is convex, the radius of average vertical curvature being approximately 60 mm. Portion exposed above the skin 30 mm. in height. The total width is 63 mm., the curvature over this line being very slight, and the portion exposed above the skin is 55 mm. in width. In shape the bone resembles a short-handled, broad-bladed hatchet with rounded cutting edge, the exposed portion of the surface being the median part of the blade. The upper rounded edge is thin, sharp, and fairly solid, thickening posteriorly to the raised central area. The remainder of the bone is virtually a housing for the infraorbital canal (*b*), and is extremely cavernous and porous. The apex of the bone is a sharp point, which is the upper origin of the main canal which runs almost straight down the bone to emerge at

the bottom of the lower projection. This lower portion of the postorbital, which is completely invested by the skin, is little else than a flattened bony tube. On the hinder margin of the upper portion of the postorbital are four large tubular openings which communicate with the main canal (text-fig. 5). There is a large dorsal pore on the top of the bone near the upper end of the canal, and three on the upper surface of the lower limb of the bone. The outer surface of the upper portion of the bone is etched out so as to give a serrated appearance. The portion of the edge of the bone which lies beneath the skin is heavily ridged and striated. In parts the surface looks as if composed of superimposed fused laminae, and the whole effect is as of elaborate sculpturing. The anterior portion of the exposed surface of the bone is excavated into pits and grooves, marginally reticulate, with one or two scattered tubercles. The middle and hinder portions of the exposed surface have deep pits and excavations roofed by membranes. The surface is also lightly pitted and grooved, and bears a moderate number of tubercles set in small pits scattered over the surface. The lower surface of the bone shows it to be composed of a solid centre from which radiate out fine tapering columnar bony structures, many of which show distal articulations resembling those of fin rays. Between these radials is stretched laminated bone which thickens inwardly. The edge of the anterior limb which lies beneath the skin, when viewed from beneath by transmitted light, shows a remarkable resemblance to a portion of a median soft fin. The centre of radiation lies on the canal slightly above the mid-line.

The right postorbital shows above the skin for the greatest height of 36 mm. and width of 57 mm. The lower margin is biconvex with a sharp excavation inwards. The hind margin is gently convex. The upper and anterior margins are somewhat irregular, having deep indentations, the inner portions of which at least are hollows in the bone, roofed by membranes. The central portion of the surface bears a number of deep excavations covered by membranes. Between these the surface of the bone is otherwise fairly smooth. Anteriorly the surface bears pits and somewhat concentric grooves. Posteriorly the surface is etched with fine grooves more or less reticulate near the margin. There is a group of scattered tubercles near the hinder angle of the bone.

Lacrimo-jugal (48) (Suborbital).

(Plates X, XI, XII, XIV, XV, and XVI; text-figs. 5 and 16.)

The lacrimo-jugal extends on each side from below the lower narial opening to the junction of the subcutaneous portions of the postorbital and the squamosal. The lower margin is in the fold of skin which forms the

inferior margin of the cheek area. The left lacrimo-jugal has been removed and freed from skin. It is a fairly long and narrow bone 110 mm. in total length, 32 mm. in greatest depth across the posterior lobe, and tapers gradually anteriorly. The upper margin of the bone is gently concave, the lower margin almost straight anteriorly, while posteriorly it curves upwards fairly sharply convex. The bone is gently convex along the main (longitudinal) axis. In addition, the two ends have a slight anti-clockwise twist from the plane of the main surface. The whole of the lower edge of the bone is sharp and thin, the upper edge is thicker, the central portion thickest, 8 mm. in thickness. In section the bone resembles an inverted triangle with very acute apex (text-fig. 16). The upper 10 to 15 mm. of the entire length of the bone is little more than a tube for the sensory canal (text-fig. 5). The whole structure is cavernous and tubular, there being numerous openings from the main canal on the lower margin of the surface, the largest being near the hinder end. That portion of the bone which lies beneath the skin is most elaborately sculptured into grooves and ridges, and the exposed surface of the bone bears numerous deep excavations roofed by membrane. Besides those are numerous shallow pits and grooves. The anterior surface of the bone is concave (beneath the eye), and has a number of scattered tubercles around the anterior margin. The posterior surface bears a few scattered tubercles, but has obviously lost a number, the pits which had contained them being visible.

Although of a very different shape from the postorbital, the structure of the lacrimo-jugal corresponds closely in that there is a central portion from which fine rays or striae radiate out, the intervening spaces being filled by laminated bone. The radial structures do not show articulations such as are observed in the postorbital. The centre of radiation is situated on the canal midway along the bone, slightly above the mid-line.

The exposed portion of the right lacrimo-jugal is approximately 97 mm. in longitudinal length. The upper margin is more or less straight with several minor excavations. The hind margin above the skin is drawn into two sharp points. The lower margin which shows above the skin is highly contorted or sculptured. The greatest depth (28 mm.) of the exposed portion lies below the hind margin of the eye. Anteriorly the surface is gently concave, the lower surface of the bone forming a broad inferior ridge. The surface of the bone bears numerous deep pits and grooves roofed by membranes, and the remainder of the surface bears shallow pits and grooves. There are a few tubercles scattered sparsely over most of the exposed surface.

Quadrato-jugal (47).

(Plates XIV, XV, and XVI; text-fig. 5.)

On the left cheek, in the area between the suborbital (48), the squamosal (24), and the preopercular (25), are three small bony studs (47) (text-fig. 5 and Plates XV and XVI). These may be the remains of an obsolescent quadrato-jugal. On the right cheek is only one such stud (Plate XIV), but its presence is significant.

Circumorbital Plates.

The taxidermist does not recollect having seen any such structures. That evidence is not of much significance since they would have been very light at most. The inner face of the circumorbital skin shows no trace of there having been any such sclerotic ring. It is probable that circumorbital plates are not present in this species. There are certainly no such structures with areas exposed above the skin.

Sensory Canal Innervation in the Cheek-bones.

(Plate XVI.)

Postorbital (23).—There are seven large foramina in the lower surface of this bone below the main sensory tube. The largest is oval, about $1{\cdot}5 \times 0{\cdot}5$ mm., the smallest minute. There are numerous small foramina feeding the branch tubes and canals.

Squamosal (24).—The main canal in the squamosal is rather short, and there are only very small innervation foramina on the lower surface of that part of the bone. These are more numerous below the porous part of the structure, *i.e.* below the hinder outer portion.

Preopercular (25).—The inferior foramina in this bone are numerous but very small—they lie chiefly on the lower surface of the hinder limb, which is extremely porous.

Lacrimo-jugal (48).—Of these bones this bears by far the biggest foramina on the lower surface. Below the hinder portion of the canal are three more or less circular foramina, about 2 mm. in diameter, spaced about 15 mm. apart. Anteriorly are five more or less equally spaced but smaller foramina. The posterior pair are rather small, but the anterior three are larger, about 1 mm. in diameter (Plate XVI).

Fronto-rostrals.

(Plates X, XI, XII, XIV, XV, XVII, XVIII, XIX, and XXI; text-figs. 3, 4, 5, 7, 11, 13, 15, 16, and 17.)

The fronto-rostral series of bones (1–22) covers most of the roof of the chondrocranium anterior to the intertemporals (49). There are a

number of primary dorsal pores (especially numerous anteriorly) formed by emarginations in the outer edges. Also the series of the two sides diverge from one another leaving a mesethmoidal opening of considerable extent corresponding more or less with the endochondral cavity R.

Excepting for a dorsal projection supero-lateral to the centre of ossification of the main frontal (1), all of the fronto-rostral bones are beneath the skin. This elongate-oval exposed portion of frontal (1) is firmly attached to the skin round its base and so provides a comparatively strong superficial linkage by the skin, by a similar arrangement with the intertemporals (49), over the fronto-intertemporal joint.

Most of the bones in this series are stello-laminate, none of them with centres of radiation in the wall of a sensory canal. Those which abut the canal have an inferior ridge, or ridge and groove.

Some of the anterior bones of the series are comparatively minute, and were discovered to be entities only after treatment with potash-alizarin. It is not surprising that these small anterior rostrals should be unknown or invisible in fossil remains. One or two from this large fish are mere fragments, a few millimetres in diameter.

Two bones in this series (1 and 17) rather tend to support the view that fusion of bones may secondarily occur. It is clearly shown by the nature and position of the bones in this series that they are primarily ossifications produced in relation to the sensory canals.

Frontal (1).

(Plates X, XI, XII, XIV, XV, XVII, XVIII, and XXI; text-figs. 3, 5, 11, 15, 16, and 17.)

There is every reason to conclude that this frontal is a composite structure, containing three separate ossifications. It consists of two distinct limbs.

The main portion of the structure is more or less laminate, 82 mm. in total length, 35 mm. greatest breadth, and 12 mm. in greatest thickness, which occurs at the hinder lateral corner where the exposed area is situated. This plate in the main is laminate and densely ossified. The exposed portion is a more or less elongate-ovoid flat-topped projection about 23 mm. in length and 11 mm. greatest width. Its surface appears to have at most only a light covering of ganoin, is mildly striated, and bears no ornamentation.

The centre of ossification of this main lamina lies immediately beneath the inner posterior corner of the exposed area of the bone, and shows clearly on the ventral surface. The lower surface is fairly smooth. The upper surface of this main lamina is much ridged and striated radio-

longitudinally. The inner edge of the lamina is almost straight, while the lateral edge has several fairly deep emarginations into which fit the hinder parafrontal bones (11–15).

The posterior edge which forms the fronto-intertemporal joint is from 2 to 4 mm. in thickness. The inner edge, where it meets its antimere along the mid-line of the head, is very thin and sharp. The bone thickens very gradually outwards, laterally, to about half-way across the width, when there arises rather abruptly the fairly heavy and wide inferior longitudinal ridge, whose outer lateral face supports the inner wall of the parafrontal sensory canal (*a*). A cross-section showing the structure described above appears in text-fig. 16. The dorso-lateral edge forms a great part of the roof of the parafrontal canal. The course of that canal shows clearly as a groove in the lower lateral surface of the bone (Plate XVIII).

A lateral anterior prolongation of the frontal (1) is overlapped by the hinder flange of frontal (2), and forms most of the floor of the sensory canal at that point. The parafrontals 11–15 fit into the latero-posterior emarginations, articulating superiorly with the frontal edge, laterally with one another, and inferiorly with the lower edge of the inner groove of the canal. As is described elsewhere (*q.v.* Sensory Canals), the main sensory canal in that part runs between and is carried by the frontals and the parafrontals.

The second main ossification in the frontal (1) is attached to the hinder lateral corner of the dorsal lamina, and projects slightly laterally, infero-posteriorly at an angle of about 70° from the horizontal. By contrast with the dorsal lamina this limb is somewhat cancellate in structure, although superficially of hard, more or less laminate bone. A similar infero-posterior projection from the frontal has been observed by Stensiö in fossil remains of *Axelia* and of *Wimania* (Stensiö, Triassic Fishes, Spitzbergen, 1921, pp. 65, 97, figs. 20 and 39, pls. 11, 12, 13, and 17). By virtue of the position, nature, and function of this inferior limb (1′), Stensiö's opinion that it represents an alisphenoid appears to be fully justified. As has been outlined previously, this alisphenoid (1′) lies upon and is firmly bound to the antotic process of the basisphenoid (42), which rests upon, and is in turn bound to, the concave face of the meta-pterygoid (35) between the ascending and the antotic processes of that bone. The frontal is thus firmly connected to the pterygoidal system. The upper surface of the alisphenoid is firmly attached by tissue to the lower face of the intertemporal (49), connecting that bone with the pterygoidal system. This frontal composite is therefore of importance in providing rigidity by linkage to the skull.

The alisphenoid is 39 mm. in length, about 22 mm. in width, anteriorly 10 mm. in thickness, becoming lamellate posteriorly. In the middle of

the anterior third is a foramen (J) 3 mm. in diameter running forwards obliquely through the bone, through which pass presumably the ophthalmic branches of nerves V and VII.

The third ossification of this frontal composite is a small lamina which forms a posterior expansion of the postero-dorso-lateral flange of the frontal. It is possibly not an extra ossification, but may be merely the enlarged latero-dorsal flange. At any rate its outer inferior margin has expanded ventrally and become fused with the antero-supero-lateral margin of the alisphenoid so as to leave a wide canal within the bone, which lies closely dorso-lateral to the nerve foramen (J). This carries the main sensory canal from the supratemporal-infraorbital junction. This is the only portion of the parafrontal canal which runs within co-ossified structures.

By function and position it is doubtful whether this postero-lateral prolongation of the frontal is a dermo-sphenotic element, corresponding to which I can find no structure in this fish.

Frontal (2).

(Plates XVII, XVIII, and XXI; text-figs. 3, 5, 11, and 15.)

This second large frontal ossification is so essentially similar to the larger posterior frontal (1) in structure and function that it is designated simply as frontal also. Its junction with frontal (1) is rather different from that between the remaining bones in the series, in that its hind margin overlaps a considerable extent of the anterior portion of the frontal (1), and by interlocking of projecting points a relatively firm suture results.

The frontal (2) is laminate, of greatest length 58 mm., greatest width in posterior third 31 mm., tapers anteriorly to a width of 18 mm., and has a greatest thickness through the inferior ridge of 6 mm. The structure is laminate, with centre of radiation slightly anterior to the geometrical centre, with a small foramen in the actual centre. The inner portion of the lamina is extremely thin, and thickens laterally but little. There is an abrupt inferior longitudinal ridge with line almost on the centre of radiation. This ridge carries in its lateral face the parafrontal sensory canal (*a*), being formed almost exactly like the similar ridge described in frontal (1). The upper lateral edge projects further laterally than the lower margin of the ridge.

The lateral edge of frontal (2) has four fairly large emarginations. Into the posterior fits the hind part of parafrontal 16, while parafronto-antorbital 17 fits against the margin containing the second and third emarginations, thereby forming two large dorsal pores.

The sensory canal (*a*) in this part is carried very much as described

under frontal (1), *i.e.* with roof and inner wall supported by frontal (2), and floor and lateral wall by parafrontal 16 and by parafronto-antorbital 17. Anteriorly the margin of (2) articulates with the posterior margin of fronto-nasal (3).

The frontal (2) is separated by an anteriorly increasing space from its antimere. Its upper surface is comparatively smooth anteriorly, posteriorly somewhat ridged and pitted, with several fairly large excavations and foramina.

Fronto-nasal (3).

(Plates XVII, XIX, and XXI; text-figs. 3, 5, 7, and 11.)

This structure lies immediately anterior to frontal (2), bordered laterally by antorbitals 17 and 5, anteriorly by rostro-nasal (6), and the interior margin partly by postrostral (4).

This fronto-nasal (3) is merely a sensory canal-supporting element. It is 21 mm. in length and 14 mm. average width. It is laminate, with somewhat undulate surface. The centre of radiation coincides with the geometric centre. Inferiorly along the middle is a ridge 5 mm. in depth, which is a continuation of the inner wall of the sensory canal (*a*). As observed also in frontals 1 and 2, there are occasional deep pits and channels in this inferior ridge. There is a deep excavation in the hind part of the inferior ridge of fronto-nasal (3), which is the posterior portion of the large foramen through which the fronto-rostral commissural canal (*r*) emerges from the parafrontal canal to pass across the snout. There are several emarginations in the outline of 3 which are parts of dorsal pores.

Rostral Elements (4, 7–10, 19).

Postrostral (4) (Plate XIX).—This is a small laminate bone, of shape figured, which lies between bones 3 and 7, bordered laterally by rostro-nasal 6. Its greatest length is 16 mm. and its greatest width 11 mm. Its centre of radiation lies at about the geometric centre. On the under surface is a slight laminate ridge 5 or 6 mm. in length and 3 mm. in depth. The fronto-rostral commissural canal (*r*) runs partly beneath the lateral edge of the bone.

Rostral (7) is a small laminate bone of shape shown in Plate XIX. It is 9 mm. long and not quite as broad. On the lower surface is a very slight ridge. On the upper surface are three relatively deep pits. The centre of radiation appears to lie on or about the geometrical centre. The fronto-rostral commissural canal (*r*) runs below part of the bone. In the anterior lateral face of 7 is a deep emargination into which fits the very small 7′ which acts as a bridge between 7 and rostro-nasal (6), forming the anterior edge of a large dorsal pore in the canal (*r*).

Rostral (9) is a small bone about 8 mm. in length and 6–7 mm. in width, which lies anterior to 7 and 7′. It is of very fine laminate structure, somewhat arched transversely, appearing to be mainly a roofing structure to the canal (*r*). I cannot distinguish any definite centre of ossification.

Meso-rostral (8) is somewhat similar in construction to, but slightly smaller than, 7. This bone forms the anterior limit of the mesethmoidal divergence of the series, and articulates marginally with its antimere on the mid-line. The junction between the fronto-rostral and the posterior rostral commissural canals (*r* and *h*) lies immediately anterior to 8. The upper surface of 8 has a number of small pits and is slightly concave. Inferiorly is a slight longitudinal ridge-like projection 1 mm. in height, which appears to be a centre of radiation.

Inter-rostral (8′).—A small almost rectangular inter-rostral 8′ lies just anterior to the capsular junction of the canals (*r* and *h*).

Rostral (10) lies anterior to 9, and is united by tissue to the lateral face of inter-rostral 8′. The surface of 10 is about 10 mm. in length and 7 mm. in width. The anterior margin is broadly convex, the posterior concave. The upper surface is somewhat convoluted, with no apparent centre of radiation. 10 bears on its lower face a large oblique inwardly directed process, 6 mm. in length and 2·5 mm. in width at the base. This inner projection appears to serve as a dividing partition where the commissural canals (*h* and *r*) diverge, *i.e.* the posterior rostral commissural canal (*h*) runs sharply downwards and forwards from the median capsular junction beneath the inner limb of 10.

Rostral (19) is a small elongate bone (Plate XIX) 9 mm. in length, with an inner triangular process embedded in the cranial cartilage. Its function is obscure, but it appears to form part of the dorsal pore system of the snout.

Parafrontals (11–16).

(Plates XVII and XVIII; text-figs. 3 and 16.)

The bones in the series which lie along the lateral face of the frontal ("para"-frontal) are all built on the same plan, with but minor variations. Each is bilaminate, transversely U-shaped, with the lower lamina generally extending farther inwards than the upper. The inner edge of the upper lamina articulates with the outer face of an emargination in the frontal (1), the lower with the infero-lateral edge of the groove in the wall of the ridge running beneath the frontal (1). As has been explained previously, there is thus formed a fairly large canal or tube partly within the frontal and partly within the parafrontals. The parafrontals meet anteriorly and posteriorly, but in such a fashion as to form longitudinally oval apertures between each, which are the main lateral pores from the parafrontal

sensory canal (*a*). Most of these parafrontals have in addition some pores or foramina in their structure.

It is exceedingly difficult to find definite centres of radiation in these structures. In some cases it appears almost as if there is a centre in each lamina, but in general the appearance suggests that the centre of ossification is the bridge between the upper and the lower laminae.

Parafrontal 11 consists of two rhomboidal laminae joined so that the upper is set more laterally than the lower. Both laminae have a fairly plain surface. In addition to the connecting ridge of bone there is a slight stirrup-like projection connecting the upper with the lower lamina posteriorly which forms a small separate lateral pore.

Parafrontal 12 is of slightly different structure, the lower lamina being very thin and flat, with a foramen near the hind margin. The upper flange is small and comparatively thick, ridged and convoluted. There is a small lateral foramen within the bridge joining the upper and the lower laminae.

Parafrontal 13 is very similar in structure to 12, with a foramen in the comparatively large thin lower lamina. The upper flange is thick, ridged and convoluted, much smaller than the lower. There is only a minute foramen through the bone which connects the upper and lower segments.

Parafrontal 14 has smaller laminae than the preceding, the lower extending not much farther inwards than the upper. The canal at this point is borne chiefly by the frontal (1), more than at any other point along that bone. There is only a minute lateral foramen through the bridge connecting the upper and lower segments.

Parafrontal 15 differs somewhat abruptly from the preceding. The upper lamina is if anything greater than the lower, both are rather thick and rugged, the whole bone being much convoluted, pitted, and channelled. The bridge uniting the upper and lower flanges is comparatively narrow. The relatively deep excavations between the flanges at each end form rather large lateral primary pores from the canal. There are numerous foramina on all parts of the bone.

Parafrontal 16 is the greatest in this series, being 27 mm. in total length. It is a fairly robust structure, much convoluted. The upper and the lower laminae have thin inner margins thickening fairly rapidly laterally. There is a longitudinal inferior ridge beneath the lower flange or lamina. The bridge connecting the two flanges is only 4 mm. in length, and the lower flange is much longer than the upper. There are several oblique foramina in the lower flange, possibly connected with the innervation of the canal.

The anterior portion of 16 fits by the projecting processes into corre-

sponding recesses of, and interlocks with, the hinder portion of parafronto-antorbital (17), so as to produce a rigid union. When so united, 16 has all the appearance of being a part of the complex 17. The parafrontals 11–14 do not interlock in this fashion. They are held in position more by their articulation within the emarginations in the lateral edge of frontal (1), so that inter-support is not so necessary as more anteriorly, where the parafrontals merely lie against the outer face of the frontal (2). There is slight interlocking between 15 and 16. This transition from loose articulation to anterior firm suturing is significant in relation to the nature of the parafronto-antorbital 17.

Parafronto-antorbital (17).

(Plates XVII and XVIII; text-figs. 3 and 5.)

There is very little doubt that 17 is a composite structure, since it shows clear indications of containing at least four co-ossified parafrontal elements, with a probably still later addition in the form of an antorbital expansion. The structure is 40 mm. in length. The inner portion is bilaminate, with flange above and below, and forms the lateral wall of the parafrontal canal (*a*). From this open four large pores, the posterior lateral, the anterior by transition becoming dorsal. Anteriorly there is a laminate lateral flange proceeding chiefly from the anterior two parafrontal elements, with an acute projection at the anterior lateral corner. There is a distinct centre of ossification near the mid-point of the inner margin of this antorbital flange.

The anterior portion of this structure 17 is almost an enantiomorph of the anterior part of frontal (2). The structure of this parafronto-antorbital (17) is of great interest in throwing some light upon the controversy about the possibility or otherwise of the fusion of ossification elements.

Rostral Bones 20, 21, and 22.

(Plate XIX; text-fig. 4.)

These bones lie almost vertical in the rostrum. There are three elements arranged as shown in text-fig. 4. There is a distant gap between the fronto-rostrals and these three bones. The latter are very light structures which demonstrably can have no tooth-supporting function, and cannot be regarded in any light as "premaxillae." They are probably the remains of a more primitive continuous fronto-rostral series of bone-elements.

The inner-rostral 20 is laminate, with a roughly square body and two lateral acute projections, the upper greater, forming a concave lateral edge. The "body" is about 6 mm. square. On the lower face is a small

laminate projection which appears to mark the centre of ossification. The rostral commissural canal (*g*) apparently runs between 20 and 21, as shown in text-fig. 4.

The mid-rostral 21 is a slender bone which has fallen into two parts. I cannot be certain whether the fracture is accidental or whether two bones are actually present. As it occurred after potash-alizarin treatment, and the faces of the junction are unstained, it is likely that it is a fracture and not an articulation.

The upper lateral limb of this bone lies over the rostral narial aperture (A). The rostral commissural canal (*g*) passes below a small flange in the foot of 21.

Outer rostral 22 is a small semicolumnar bone set obliquely lateral to the rostral tube (A), so as to form with 21 a bony ring support for that channel. This bone has also split into two parts, almost certainly not a suture.

The rostral dental plates (90) are supported almost entirely by the extremely thick and strong skin of the rostrum. The slight rostral skeleton can hardly add much to the strength of that part.

Naso-antorbital (5).

(Plates XVII and XIX; text-figs. 3, 5, and 7.)

This bone is structurally somewhat difficult to interpret. It represents almost a transitional form between the anterior portion of the composite 17 and the larger canal ossification such as frontal (2). There are indications that it contains two fused parafrontal elements and a lateral antorbital ossification, but this is not so obviously shown as in the case of bone 17.

This antorbital is 22 mm. in length, 19 mm. greatest width, and transversely fairly convex. It is laminate, somewhat ovoid, with the hinder lateral margin expanded and somewhat serrate. The upper surface is uneven, with moderate grooves and ridges. Two large pores open from the canal on the inner part of the surface.

Inferiorly is a longitudinal ridge which forms the lateral wall of that part of the parafrontal canal (*a*) where it trifurcates, inwardly into canal (*r*) outwardly and laterally to meet the infraorbital canal (*b*), and anteriorly to run around the inner face of the naso-rostral 18.

The apex of 5 rests upon the front flange on the hinder edge of rostro-nasal 18, and the inferior ridge is supported by a long postero-inferior process of that same bone (*q.v.*). 5 articulates with bones 17, 3, 6, and 18.

The centre of ossification is not obvious, but it appears to lie just lateral from, and anterior to, the large inner posterior pore.

Rostro-nasal (6).

(Plates XVII, XIX, and XXI; text-figs. 3, 5, and 11.)

This bone lies at the centre of the rostro-nasal system. Its outline is much excavated, forming part of the numerous dorsal pores which are present in this area. 6 is an important bone in its relation to the sensory canals, and it articulates with bones 3, 4, 5, 7′, and 18. The upper surface is slightly ridged and pitted, and gently convex. The shape is difficult to describe; the bone is shown in Plate XIX. Its greatest length is 16 mm. and its greatest width is 14 mm. The superficial portion is laminate.

Posteriorly is an apically dilated limb which articulates with fronto-nasal (3). Beneath the base of this limb is an inferior, rather acute process 8 mm. in length and about 4 mm. across the base, which projects backwards and downwards. This forms the anterior margin of the large pore in the inner wall of the parafrontal canal through which the commissural canal (*r*) issues.

The parafrontal canal runs beneath the hinder lateral edge of 6, continuing down beneath that bone round the inner face of naso-rostral 18. The fronto-rostral commissural canal (*r*) runs beneath the inner face of 6.

The lower surface of 6 is deeply concave anterior to the inferior process, with a pit at the foot of that process in which appears to lie the centre of ossification. Here again ossification has originated next to a canal system, has proceeded above and below the canal, and has also produced a laminate contra-expansion.

Innervation of the Parafrontal Canal System.

In the antero-lateral flange of the alisphenoid (1′), which underlies the canal, are several minute, possibly innervation, foramina. Parafrontal 16 also possesses several oblique foramina (*q.v.*). Otherwise there are no indications that the innervation of the parafrontal canal occurs by transmission through any part of the ossified walls. In some parts, *e.g.* the hind lower edge of the infra-frontal (1) ridge, there is a slight groove leading to the canal from the foramen (J), indicating direct supply from the main trunk of the nerve.

As described under Sensory Canals, the parafrontal canal proper is nowhere entirely encased in bone. The floor of the canal is posteriorly partly cartilage, increasingly so anteriorly. The innervation is doubtless through the cartilaginous floor.

Lateral Rostro-nasal (18).

(Plates XVII, XIX, and XXI; text-figs. 3, 4, 5, 7, and 11.)

This bone is situated at the side of the rostrum, its base resting in a notch on the lower portion of the outer face of the ectethmoid (38), its lateral limb resting against the upper part of the face of the columnar process of that bone. The lateral limb anastomoses with the anterior end of the suborbital (48). The upper limb of the rostro-nasal is overlapped by the lower lobe of the naso-antorbital (5), and slightly below and inwards by rostro-nasal (6) (text-fig. 3). The body of the bone forms the anterior wall of the olfactory capsule (E) (Plate XXI).

The shape of the bone (18) is difficult to describe, but it is figured in Plate XIX. The ossification has very obviously been developed in relation with the sensory canal system. Canals run round the margin and within the bone for at least four-fifths of its periphery. The centre of radiation lies near the inner margin of the main body of the bone.

In structure the body of the bone is light, but firmly ossified. The more distal parts are laminated and densely ossified.

The lateral limb is merely a tube with two elongate-oval apertures facing upwards and outwards. The inner margin of the bone is excavated into a deep groove with a uniform flange behind, and with a doubly emarginate flange anteriorly. Towards the lower part of the inner margin the two flanges fuse distally to form a short tube which opens into a shallow groove on the lower face and ends on the slightly dilated "foot" of the structure.

On the inner face of the lateral tubular limb is developed an elliptical facet for articulation with part of the columnar process of the ectethmoid (38) (the corresponding facet on that bone (38) may be seen, Plate XXII).

This rostro-nasal is an important bone in the sensory canal system of the head. Over the upper hinder flange, turning outwards (lateral), is the junction between the parafrontal and the infraorbital canals (*a* and *b*). This junction is continuous with the canal running round the inner margin of 18 (text-fig. 3). This rostral branch of the parafrontal canal receives the two rostral commissural canals (*g* and *h*) (text-figs. 3, 4, and 5).

On the inner face of the bone along the course of the canal system are several small foramina, possibly for innervation. There are also several larger foramina in the back of the body of the bone (which is porous), which appear to communicate through the bone with the base of the trough of the canal groove which runs round the upper and inner edge of the bone. There are also numerous small foramina on the postero-dorsal slope of the lateral tubular arm of the bone which probably are connected with the innervation system.

Intertemporals (49).

(Plates X, XI, XII, XIV, XV, XVII, XXI, and XXVIII; text-figs. 2, 5, 11, 13, 17, and 18.)

The intertemporals form the chief portion of the bony roof of the cranium. They appear to be more firmly united along the median suture than are the frontals, and are much heavier bones. There are no tubercles on the exposed surface of the intertemporals, though there are several pits which might have contained them. The portion exposed above the skin is approximately half of the total superficial area, and lies latero-anteriorly. This portion of the bone is divided into three main areas by grooves, a small, fairly deeply excavated groove demarcating a small area at the infero-anterior corner. The main groove is paraboloid and defines the hind limb of the exposed surface. Medially within the anterior part of this section is a short longitudinal groove. The base of these grooves consists partly of membrane, which is a roof to sensory tubules within the bone. The surface is generally striated and convoluted, with centre of radiation approximately at the nose of the paraboloid groove. The hinder upper margin of the exposed surface is deeply concave. On the inner edge of the exposed surface is a rounded projection. The greatest length of the exposed portion of the left intertemporal is 59 mm. and width 44 mm.; length of exposed portion of right intertemporal 58 mm., greatest width 44 mm.; length of the surface of the whole intertemporal 77 mm. and greatest breadth 67 mm.

The anterior edge of the intertemporal does not articulate above with the hind margin of the frontal (1), but they meet below, the system comprising the characteristic fronto-intertemporal joint (*q.v.*). A small projection from the anterior edge of the intertemporal almost touches the outer surface of the alisphenoid. Time and circumstances have not permitted of a dissection of this region, but the general character of the intertemporal has been determined. Along the medio-sutural line the intertemporals are radio-laminate. About 20 mm. from the inner margin there is an abrupt, ventrally directed longitudinal ridge. At the anterior end of the ridge the bone is 8 mm. in depth, but increases posteriorly as this ridge becomes higher. The ridge is trenchant, and forms the upper lateral support for the chondrocranium in that region. About 65 mm. from the anterior margin of the intertemporal the cartilaginous floor of the superior fossa temporalis joins that lining, the lower surface of the intertemporal forming the posteriorly sloping posterior surface of the cranial cavity. The apex of the fossa temporalis is formed by a conical fossa in the intertemporal itself.

The main sensory canal (*f*) runs in a tube through the bone along the lower lateral edge of the intertemporal, and ends anteriorly 20 mm. behind its anterior outer angle, where the under surface of the bone acts merely as a roof for the canal. Just in advance of the anterior end of the main tubule, 15 mm. from the anterior margin of the intertemporal, is a dorsal branch of the sensory canal which appears to run almost 20 mm. dorsomedially (text-fig. 2). It must branch in all directions, since the upper portion of the bone is extremely porous, and side tubules from the dorsal branch are visible, and may be traced all round the edge of the exposed portion of the bone.

Supratemporals (50).

(Plates X, XI, XII, XIV, XV, XXI, XXVI, and XXVIII; text-figs. 2, 5, 11, and 13.)

The supratemporals lie immediately posterior to the intertemporals (49). The anterior face articulates with and is closely joined with the latero-posterior face of the intertemporal beneath the skin. The two bones are definitely not fused, but time and circumstances have not permitted me to separate them. The exposed portion of the left supratemporal is 40 mm. in length, 20 mm. in width, broadly hastate with anterior apex. The surface bears a number of pits and short grooves. The right supratemporal is 35 mm. in length and 22 mm. in width, somewhat similar in shape to the left but with more dermal invasion of the surface, the outer margin being somewhat irregular. Considerably less than half of the dorsal surface of the left supratemporal is exposed above the skin; the unexposed portion lies chiefly postero-dorsally.

The total length of the supratemporal is 70 mm. and its greatest width 38 mm. The hinder limb beneath the skin is deeply concave, and forms the lateral surface of the dorsal fossa temporalis. The lower hinder corner of the supratemporal is expanded ventrally beneath the skin. The slightly oblique hinder face bears a moderate facet for the articulation of the antero-superior opercular process, the whole being enveloped in the hyomandibular cartilage. The anterior portion of this inferior projection is produced downwards, forwards, and slightly inwards into an elongate lamina (50′), 41 mm. in length, which articulates by overlapping with the upper outer hinder face of the prootic (93) beneath the capsular ossicle (92) (text-fig. 11 and Plate XXVIII). A smaller, inwardly directed horizontal process from this downward process 50′ articulates with an outwardly projecting similar structure from the inner lower ridge from the intertemporal (49).

Postspiracular (51).

(Plates X, XI, XII, XIV, XV, XXI, and XXXII; text-figs. 2, 5, and 11.)

This structure lies at the posterior extent of the postspiracular groove (T) between the intertemporal-supratemporal suture and the upper hinder margin of the postorbital (23).

That of the left side has been removed and, like the subopercular (27) and the interopercular (26), proves to be merely a modified scale. The exposed surface is roughly oval, 18 mm. in length and 8 mm. in height. This bears dorsal and ventral dermal flanges set at almost right angles to the exposed surface. The upper flange is about 3 mm. and the lower 5 mm. in height, both being rather thin with sharp edges. These flanges continue beneath the skin anteriorly, diverging somewhat, and are connected by a dermal expansion originating below the anterior margin of the exposed surface. This antero-inferior expansion is deeply emarginate anteriorly, and the degree of ossification diminishes rapidly towards the margin, which is cartilaginous.

The whole structure from above resembles a rather elongate arrow-head. In transverse cross-section the ossicle is very strongly arched. The whole structure resembles a trough, of which the exposed surface is the bottom and the dermal flanges the sides. The hollow portion is filled with very oily spongy tissue. On the exposed surface are a number of rounded tubercles, between which the surface appears to bear a thin coating of ganoin.

The postspiracular of the right side is somewhat larger (Plate XIV), but obviously of similar structure.

Extrascapulars (55–59).

(Plate XXX; text-figs. 2 and 5.)

The extrascapulars are in this fish small tubular ossifications, the outer pair indeed being merely roofing structures for the occipital sensory canal (*f*). They form an undulating chain across the occiput with a central composite inter-extrascapular (55). The whole system of nine elements lies immediately beneath the skin, being held firmly in position by a stout periosteal membrane in which the tube is continued between the individual structures. The mouths of the tubes are separated one from the other by a space of several millimetres.

There is a medial composite inter-extrascapular (55), and on each side four small units, the first, second, third, and outer extrascapular (59). This system is possibly a remainder by reduction of dorsal ossifications,

for these tubular bones may easily have originated by modification of tubules such as those carried by the first few lateral-line scales. The tubules in 55, 56, and 57 resemble the tubules of the anterior lateral-line scales, but are larger. There is differentiation between these bones and the other canal-bearing bones of the head, in that none shows any centre of radiation. On the occiput, adjacent to the canal, is a small bony stud (95) in the skin, which may be the remains of the superficial occipital ossifications. It resembles those studs in the quadrato-jugal region (47).

INTER-EXTRASCAPULAR (55).

This bone lies immediately beneath the skin on the mid-line of the occiput. It consists of a more or less capsular central portion from which radiate out numerous tubules. On each side is the main anterior limb anastomosing with the first extrascapular (56). Medio-anteriorly on the capsule is a large pore. Posteriorly to that part in contact with the under surface of the skin radiate out four main tubes and several minor tubules. The dorsal surface of the capsule contains numerous small pores leading to the skin.

The main capsule is about 14 mm. in diameter and 8 mm. in thickness. The apices of the main anterior limbs are 24 mm. apart internally. The structure is laminate with no obvious centre of radiation.

FIRST EXTRASCAPULAR (56).

This extrascapular anastomoses with the lateral limb of 55. It is a tubular structure, fairly simple, of laminate bone, somewhat convoluted, with the ends moulded for each anastomosis. Its length is 18 mm., outer diameter 6 mm., inner 3 mm. In the dorsal surface are relatively large foramina, while on the ventral surface, near the anterior margin at the centre of the bone, are three forwardly directed spiniform processes. Posteriorly there are a number of pits.

There are three side branches to the main canal in this bone, two anteriorly and one posteriorly. There is no obvious centre of radiation.

SECOND EXTRASCAPULAR (57).

This is a tubular structure of somewhat irregular shape, 15 mm. in length, outer diameter about 5 mm. and inner about 3 mm. The ends are to some extent moulded by dilation to allow for the bending of the canal at this point. The dorsal surface contains numerous pits and excavations, while midway along the anterior side is an antero-inferior spiniform process. There is no obvious centre of radiation.

Third Extrascapular (58).

This lies between the outer extrascapular (59) and the second extrascapular (57). It is a laminate bone curled about the long axis for about four-fifths of the extent required for the edges to meet and form a tube. It is almost a tube, only a portion of the floor being open. Its length is 13 mm. and the diameter of curvature about 5 mm. The bone is of the same type as 59, merely curled to a greater extent, and contains foramina and internal excavations. It forms the roof and sides of the canal. There is no obvious centre of radiation.

Outer Extrascapular (59).

This is merely a more or less rectangular laminate ossification with rounded corners, and with the long edges curled slightly downwards. It forms the roof of the canal over the depression containing the end of the canal in the upper hinder surface of the supratemporal (50).

There are numerous foramina in the bone, and a spiniform dorsal process near the mid-point of the anterior edge. Its anterior end is close to the postero-lateral end of the third extrascapular (58). Its length is 14 mm., width 9 mm., the bone being at most 1 mm. in thickness. There is no obvious centre of radiation.

Sensory System.

(Plates XVII and XXV; text-figs. 2, 3, 4, 5, 7, 9, 15, 16, 17, and 18.)

In the main the sensory canal system in the Coelacanthid head appears to differ but little between the genera. The present specimen indicates that most of the recent authoritative reconstructions have probably been very close to the truth.

In the present specimen the courses of the main canals have generally been very plainly shown by encasing bones. To some extent the actual shape and size of the internal cavities have been difficult to determine exactly, since that would have meant opening the bones, which I could not contemplate. Some portions of the canals have been exceedingly difficult to determine, since the tissues beneath the skin had been torn and scraped away. In the following description any doubtful points are clearly indicated.

Isolated pit-organs are not obvious either on the head or the body. They would in any case be difficult to identify, since everything had been soaked in oil, and later heavily varnished (though most of the latter has been removed by washing with chloroform subsequently) I cannot find definite pit-lines such as have been stated to have been found in several

extinct forms. The sensory system in the dermal bones of this specimen is very complex, but practically every part of it is directly connected with the main canal system. Almost the whole of each bone is porous and channelled within, presumably everywhere connected with the main canal. Innervation foramina are generally visible beneath the porous area as well as below the main canals. Above those parts connected with the sensory canals the surfaces of the bones are much sulcated, the bottom of the grooves being membranous. On the cheek-bones all this may clearly be seen in Plate XVI, and the approximate degree of excavation within the bones is shown in text-fig. 5.

The angular and splenial have no definite pit-line, though in each there are several sensory grooves and large pits; in the former these run along the line of the canal, almost regularly spaced. The hinder limb of the mandibular canal ends in an extensive membrane-roofed groove. As has previously been stated, the gulars possess isolated sensory grooves and large pits.

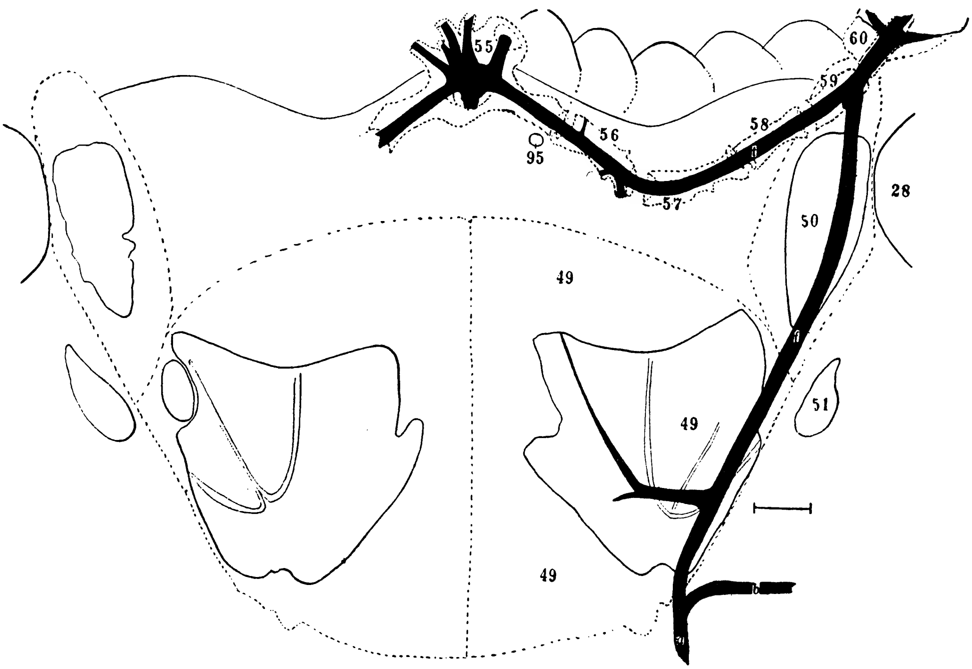
It is possible that the canal system of *Latimeria* represents the general plan for all Coelacanthids. Variations shown for certain genera and species are probably due to distortion of the structure.

Occipital Region.

The main canal system of the occipital region has been determined in detail. The lateral line from the trunk joins the head through the tubule of the first lateral-line scale (60) (text-figs. 2, 5, and 17; Plates X, XV, XXI, and XXX), whose anterior opening lies over the end of the supratemporal (50). At this point, about ·6 mm. from the hind end of the supratemporal, is a depression into the bottom of which the tube through the supratemporal runs obliquely. This depression is covered partly from behind by the anterior opening of the first lateral-line scale, anteriorly by the hind margin of the convex, laminate outer extrascapular (59), whose hind margin articulates with the upper anterior portion of the tube of the first lateral-line scale. The canal rising from the supratemporal thus divides into a posterior branch which is the lateral line of the trunk, and an anterior which is the supratemporal commissural canal (*t*) of the occipital region. More properly the supratemporal canal (*f*) might be regarded as an infero-anterior offshoot of the canal of the lateral line which is continuous across the occiput.

From this junction on the supratemporal, the supratemporal commissural canal (*t*) runs almost parallel with, and just in advance of, the anterior margin of the scaling on the nape. The canal runs upwards and forwards, first beneath the laminate outer extrascapular (59), then beneath

the third extrascapular (58), continuing forwards through the second extrascapular (57). Towards the end of the tube in that bone (57) the canal turns to a transverse course, and thence upwards but obliquely backwards through the first extrascapular (56), then through the left lateral limb of the inter-extrascapular (55), where it meets its fellow from the opposite side.



TEXT-FIG. 2.—*Latimeria chalumnae* Smith. Sensory canal system of occipital region. Canals in black. Bone surface above skin with uninterrupted, below skin with interrupted, outline. The line represents 1 cm. For explanation see Folder-page I at end.

Only in the first extrascapular (56) are there any branches from the main canal. It is possible that branches may occur between the ends of the comparatively widely separated extrascapulars, but I was unable to examine the under surface of the skin in that part of the head to determine this. The inter-extrascapular (55) is radio-tubulate with five posterior and one large anterior branches.

Innervation.—There is little to assist in determining the mode of innervation of this canal. Laterally, where the canal has a roof only, this is obviously transmitted through the soft floor. Bones 56 and 57 do not appear to have any even minute foramina in the ventral surface, though there are a few on the posterior face of each. There are none in the floor

of the capsule of the inter-extrascapular but a number on the anterior slope of the capsule above, sheltered by a superior flange below the main anterior branch of the canal. These may be the innervation foramina. It is most likely that the main innervation occurs between the bones of the system.

Supratemporal Canal (*f*).

(Text-figs. 2, 5, 17, and 18.)

From the posterior dorso-lateral end on the supratemporal (50) the tube passes downwards very obliquely through that bone, running towards the lateral edge. It passes into the intertemporal (49), in which it apparently runs close to the lower lateral margin. About 30 mm. behind the front margin of the intertemporal is the anterior aperture of the tube. The canal runs thence forwards roofed by the lateral ridge of the intertemporal.

There are indications of side tubules and branches in the supratemporal although that bone is comparatively solid. The intertemporal is, superficially at least, apparently cancellate or porous in structure, and there are doubtless very numerous small branches from the main canal. There is one large dorsal branch in the intertemporal, which originates in the roof of the groove above the anterior portion of the main canal. It runs almost transversely upwards near the surface of the intertemporal (49), as shown in text-fig. 2. Only one branch from that dorsal section can be traced with certainty. It runs upwards and backwards, ending at the upper hind margin of the exposed portion of the bone as a membrane-covered depression. Since numerous other similar depressions are present round that margin, there are doubtless very many branches from the main canal as well as from the main dorsal branch.

Parafrontal Canal (*a*).

(Text-figs. 2, 3, 5, 7, and 16.)

From beneath the roof of the intertemporal lateral edge the main canal passes forwards and downwards to run through the upper outer foramen above the "alisphenoid" (1′), *i.e.* the hinder limb of the frontal (1), below but lateral to the fronto-intertemporal joint. It emerges from the foramen of the alisphenoid beneath the superior lateral flange of the frontal (1), and runs along the lateral margin of that bone.

The nature of the canal in this part is more "parafrontal" than supraorbital. In no part in advance of the alisphenoidal foramen is it carried by a bone-encased tube, but travels between more or less articulating bones. As is mentioned elsewhere, if bone fusion is accepted, the foramen

along the "alisphenoid" (1′) has been formed by fusion of the lateral margins of the alisphenoid and of a parafrontal element (likely not a dermosphenotic by function), after both had fused internally with the lateral margin of the frontal.

Along the lateral edge of the frontal (1) the canal is formed as follows: the inner wall entirely, and the floor only partly by the frontal (see Plate XVIII); the floor posteriorly only partly by the inner lower flanges of the parafrontals 11–16; the roof chiefly by the dorso-lateral flange of the frontal (1), partly by the inner superior flange of the parafrontals; the lateral wall by the lateral rounded portion of the transversely U-shaped parafrontals. The system is extremely open, the parafrontal bones being so formed that there is a large pore opening laterally between each pair. The first large pore is formed between the hind outer margin of the first parafrontal (11) and a gap in the outer edge of the foramen above the "alisphenoid," where it emerges laterally and anteriorly. Along the edge of the frontal (1), behind its articulation with frontal (2), there are so formed six large lateral pores. The first (posterior) pore, behind the first parafrontal (11), appears to have a posterior expansion along the edge of the frontal (1).

The canal widens somewhat anteriorly and continues undivided along the lateral edge of frontal (2), roofed partly as before by the dorso-lateral flange of that bone. Its outer margin and the lateral part of the floor are formed by parafrontals 16 and the composite 17. The series of lateral pores is continued, the seventh large pore being between the anterior margin of 16 and the posterior margin of 17. The following five pores in that series gradually change from lateral to dorsal over the surface of the fronto-antorbital (17), the last being on the surface of bone 5. In addition to these latero-dorsal pores there now commences a series of anteriorly increasing pores in the roof of the canal. The first is formed between the lateral margin of frontal (2) and the inner margin of parafrontal 16, the second and third between frontal (2) and the dorso-inner flange of parafrontal 17. Beyond this third pore the anterior margins of 2 and 17 diverge and the fronto-nasal (3) comes between them. The fourth large pore is formed between the three bones mentioned (2, 3, and 17).

It is characteristic of the parafrontal canal that it becomes somewhat wider anteriorly, and the bone encasement less, chiefly in the floor. Between bones 3 and 5 there is scarcely any bony support for the canal below.

The canal continues between the outer margin of 3 and the inner margin of the naso-antorbital (5), with the fifth large dorsal pore formed by emarginations in their contiguous edges. Anterior to the articulation between 17 and 5 on the lower third of the latter, the parafrontal canal (*a*)

divides, the outer or lateral portion passing beneath the inner margin of 5, thence over the hinder dorsal flange of the latero-rostro-nasal (18), turning sharply latero-posteriorly through the tube in the postero-lateral limb of 18, to join the infraorbital canal (*b*) at its exit from the anterior end of the suborbital (48). At the lower corner of 5 there is another bifurcation, the inner limb passing round the inner furrowed edge of 18, where the posterior rostral commissural (*h*) joins, thence to the lowest anterior point of 18, where the rostral commissural (*g*) ends.

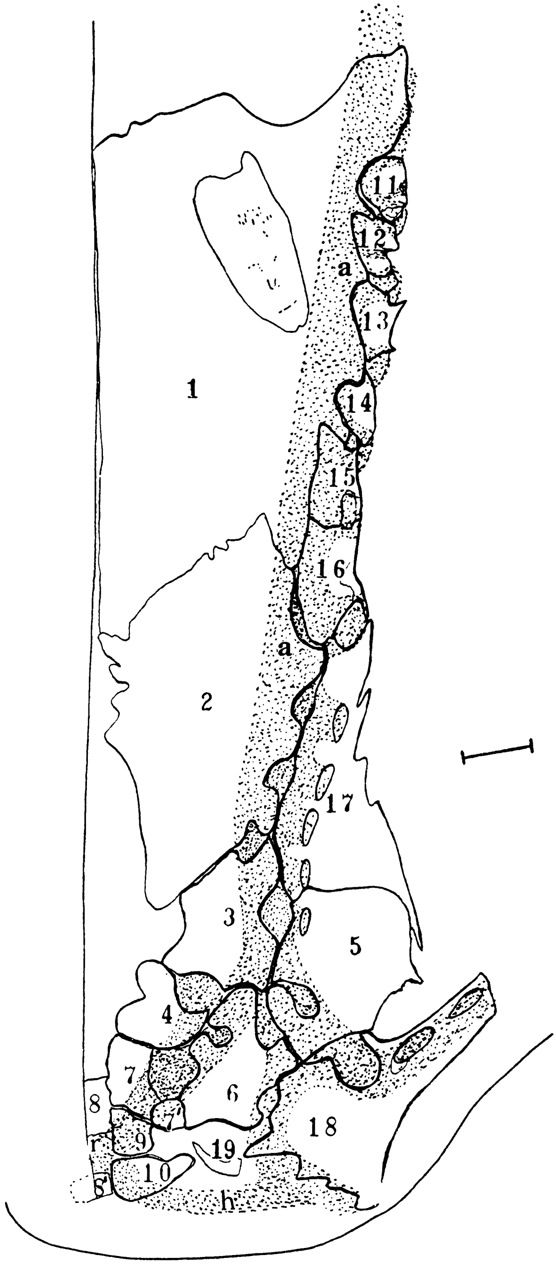
The parafrontal canal has in all 17 primary pores—10 latero-parafrontal, 3 dorso-frontal, and 4 ethmo-rostral. The innervation of this canal has been discussed elsewhere (*q.v.*).

Rostral Commissural Canals (*r*, *h*, and *g*).

(Text-figs. 3, 4, 5, and 15.)

The condition of the specimen has made it extremely difficult to determine exactly the course of each of these three canals. The skin on the snout has set to an almost metallic hardness and the tissues within have shrunken with some degree of decomposition, so that the tracing of the course of the anterior rostral commissural canal (*g*) with absolute certainty has proved almost impossible. The course of neither (*g*) nor (*h*) is defined by bones only, but passes through subdermal tissue. Only in the case of the fronto-rostral commissural canal (*r*) has the course been determined beyond doubt, since it is bordered by inferior processes or flanges of the rostro-nasal series of bones.

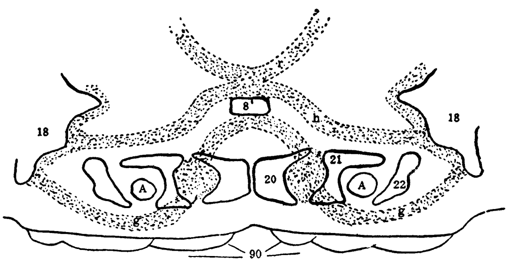
The Fronto-rostral Commissural Canal (*r*).—By the sutural union of the recessed inferior longitudinal processes of fronto-nasal (3) and rostro-nasal (6) is formed a large foramen which is the junction between the parafrontal canal (*a*) and the fronto-rostral commissural canal (*r*). This latter is fairly broad, but not so great as the parafrontal canal (*a*). It runs forwards and inwards, at first beneath the hinder inner portion of rostro-nasal (6), partly beneath rostrals 7, 7′, and 9, and finally meets its fellow on the mid line as a purely dermal canal immediately anterior to the meso-rostral (8). At its junction it also unites with the posterior rostral commissural canal (*h*), forming a central cavity which lies between meso-rostral (8) and inter-rostral (8′), from which on each side (*r*) runs upwards and backwards and (*h*) forwards and downwards. Between the junction with the parafrontal canal (*a*) and the small median capsular junction there are three large pores above this fronto-rostral commissural canal (*r*). The first lies above and inwards from rostro-nasal (6), being bordered by that bone and by the bones 3 and 4. The second, anterior to the first, is small, and lies almost wholly within the surface of 6. The



TEXT-FIG. 3.—*Latimeria chalumnae* Smith. Dorsal view of fronto-rostral series of bones on left side. Sensory canals shown by dotted areas (see Plate XVII). The line represents 1 cm. For explanation see Folder-page I at end.

anterior and largest pore is bordered by 4, 6, 7′, and 7. I am inclined to think that the large open area between the fronto-rostral series on the mesethmoidal area (above the cavity R) may be connected with this commissural canal. Also anterior to bones 6 and 7′, posterior to 10 and 19 and between 9 and 18 (see text-fig. 3), are two large dorsal pores bordered partly by tissue which may possibly connect the canal (*r*) with the canal running round the inner face of the latero-rostro-nasal (18). Those two openings suggest that they are sensory canal pores.

Posterior Rostral Commissural Canal (*h*).—From the central capsular junction with commissural canal (*r*), the canal (*h*) runs sharply downwards and forwards, beneath the inner portion of rostral 10, over inter-rostral 8′ to above rostral bone 21, whence it appears to turn sharply, latero-horizontally to join the canal on the inner face of bone 18 (see text-figs. 3 and 4).



TEXT-FIG. 4.—*Latimeria chalumnae* Smith. Sensory canals of rostrum shown bydotted courses. About natural size. For explanation see Folder-page I at end.

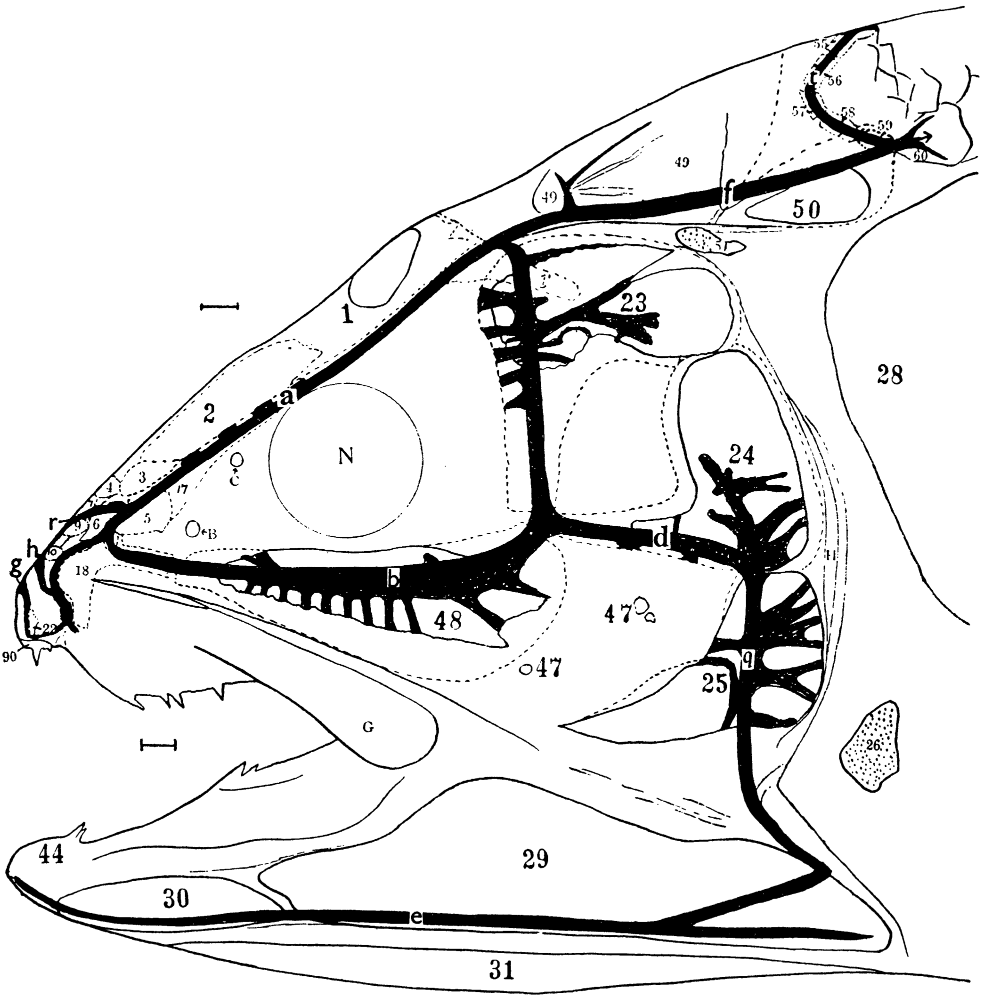
Rostral Commissural Canal (*g*).—The only portion of this canal that can be determined with any certainty is the median portion immediately anterior to inter-rostral 8′. The canal turns sharply forwards and downwards with apparently a large dorsal pore between rostrals 20 and 21 (this shows externally on each side as a large depression in the shrunken skin internal to the rostral narial opening (A) (see Plates X, XI, and XII)). In so far as I can determine this canal now passes forwards, turning laterally over the foot of rostral 21, thence upwards beneath rostral 22 to join the main canal system at the inner side of the foot of latero-rostro-nasal (18). It is possible that the commissural canal (*g*) joins into the posterior rostral commissural canal (*h*) above the rostral 21. The nature of the skin in that part led me to believe that the commissural canal (*g*) ran principally that way. More careful study of that part appears to confirm the canal system here outlined and as shown in text-figs. 3 and 4.

In my opinion it is not unlikely that almost the whole of the surface of the rostrum, in advance of rostro-nasals 6 and between latero-rostro-nasals 18, is directly connected with the sensory canals. Commissurals (*g*) and (*h*) represent merely the main channels in those parts, and are probably interconnected by numerous smaller channels.

INFRAORBITAL CANAL (*b*).

(Text-figs. 2, 3, 5, 7, and 16.)

The dorsal branch of the infraorbital canal runs almost vertically through the postorbital (23), on a line well behind the anterior margin



TEXT-FIG. 5.—*Latimeria chalumnae* Smith. Left side of head showing main sensory canals in black. Bone surface above the skin outlined by unbroken lines, that beneath the skin by broken lines. Canals within bones not accurately to scale for size. The line represents 1 cm. For explanation see Folder-page I at end.

of the intertemporal (49). Unfortunately the inner surface of the skin within the area of the junction between the supratemporal-parafrontal

and the infraorbital canals had been scraped and all loose tissue torn away. (This part had been damaged and sewn up rather coarsely.) The precise point at which the infraorbital canal joins the superior canal could thus not be determined with certainty. That its junction is posterior to the fronto-intertemporal joint is almost certain. There is no point at which this large canal could have united with the parafrontal canal (*a*) anterior to the fronto-intertemporal joint without its having been very much constricted.. From what I have been able to determine, it appears that the junction occurs on the dorsal face of the alisphenoid (1′) immediately posterior to that foramen for the canal, previously described, in the frontal (1).

The main infraorbital canal (*b*) runs almost vertically downwards through the postorbital (23), turning forwards into the suborbital (48) at the anastomosis of the hind end of the canal in the latter with the lower end of the canal in the former.

There are several main subsidiary branches of the canal in the postorbital: four on the anterior upper portion and three posterior, with numerous smaller channels which cannot be determined with accuracy. The infraorbital canal (*b*) now runs forward through the suborbital (48) to join the parafrontal canal (*a*) in rostro-nasal 18. In the suborbital are numerous branches of all sizes. Only those shown in the figure are fairly accurately determinable. The suborbital is porous and canalised, so that all parts of that region must receive some supply from the main canal. There appear to be 15 main sensory organs in the course of the infraorbital canal.

Jugal Canal (*d*) and Preopercular Canal (*q*).

(Text-figs. 5, 17, and 18.)

At the anastomosis of 23 and 48, the anterior limb of the squamosal (24) anastomoses also and carries posteriorly the main jugal canal. The posterior limb of the squamosal has large side apertures and many smaller openings, and there are two main inferior pores below the anterior limb. The canal runs through the squamosal and curves down to emerge on its lower edge directly into the canal in the upper anterior edge of the limb of the preopercular (25). In the preopercular the canal runs vertically downwards, to emerge near the hinder part of its lower edge. In the preopercular (25) are several determinable large branches and a number of finer channels and canals. From its emergence from the preopercular the canal is carried in a wide tube in the thick skin enfolding the lower jaw, and curves down and back over the lower outer face of the quadrate (34).

Mandibular Canal (*e*).

(Plate XXV; text-figs. 5 and 9.)

This originates in the upper hinder portion of the angular (29), where the dermal canal from the preopercular curves forwards abruptly, to run obliquely downwards towards the lower margin of the angular. The canal then continues forwards in the angular very close to the lower outer margin of that bone. From the main canal there are very many side convolutions into the angular-gular articulation groove which are not shown in text-fig. 5. That portion of the otherwise solid angular is much excavated into channels and grooves roofed externally by membrane (Plate XXV). There is a line of large pits in the bone just above, and communicating with, the canal.

The canal (*e*) passes from the angular into the splenial (30), in which it runs at first within the lower outer margin, but rises anteriorly to emerge higher in that bone, and thence to the symphysis. I cannot determine whether the two canals (*e*) meet across the symphysis.

From the main canal is a hinder branch which runs along the lower surface of the angular almost to the hind margin of the exposed portion. The canal comes to the surface at the hinder end, opening as a posteriorly diminishing excavation roofed by membrane (see text-fig. 5).

Olfactory Organs.

(Plates X, XI, XII, XIV, XV, XXI, XXII, XXV, and XXVII; text-figs. 4, 6, 7, 11, and 15.)

In the ethmoidal region, just below the surface, lies a median cavity or sinus (R) whose apex is 24 mm. from the tip of the snout. This sinus is contained in the ethmoidal cartilage, and is roofed by a thin layer immediately below the gap between the fronto-rostrals. It is more or less depressed biconical in shape, 58 mm. in length, 19 mm. greatest depth on the mid-line, and about 35 mm. in width. The hinder part of the floor is a thin layer of cartilage which roofs the cranial cavity containing chiefly the ~~optic~~ olfactory lobes (L) of the fore-brain. The side of the hinder end of the sinus R is overlapped by frontal bone 2. Into it (R) lead six tubes from external openings. Anteriorly are two, one (A) from each side of the front of the rostrum. There are on each side two lateral apertures (B and C), placed much as the usual external nostrils of Teleosts, on the side of the snout before the eye, one above and behind the other. All six tubes are simple, and the openings are plain, without dermal fringes or cilia. The inner parts of the tubes and of the sinus appear to have had a membranous lining, with somewhat rugose or ridged surface. The most

careful examination of the walls of the central cavity has failed to reveal the faintest aperture or opening through the cartilage other than the three tubes on each side. The innervation of the membranous lining appears to be from the ophthalmic branch of the V nerve as described below.

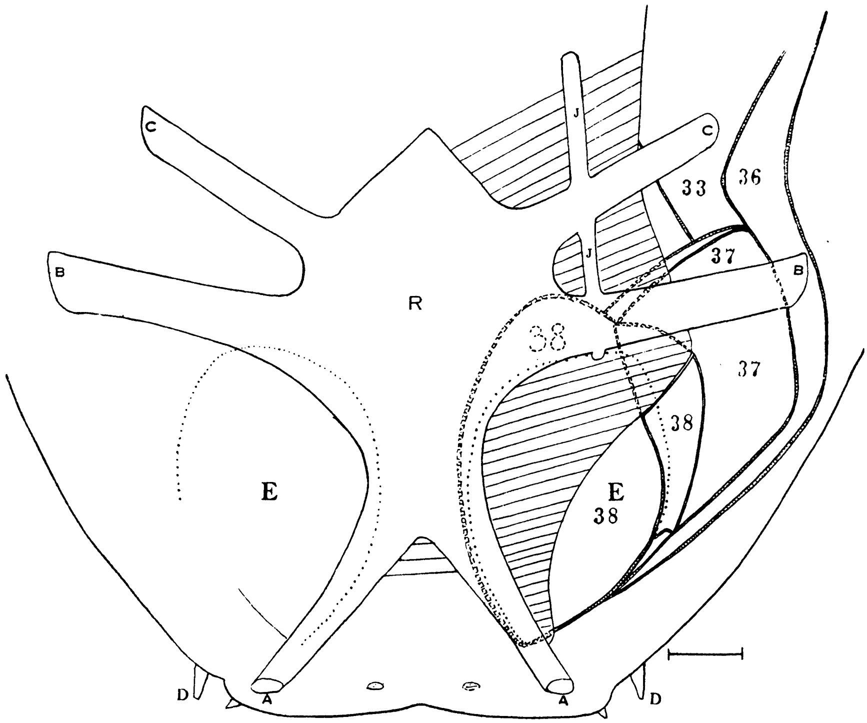
The rostral aperture (A) lies near the lateral edge and is 3 mm. in diameter. Inward from this aperture on each side of the front of the rostrum is a pit of slightly smaller diameter (see Plate XII) which marks a surface pore in the rostral commissural canal (*g*). The tube from each rostral opening curves upwards and inwards, running beneath the rostral commissural sensory canals (*g*, *h*, and *r*) and along the inner wall of the olfactory capsule (text-figs. 3 and 6), dilating posteriorly, the two openings being adjacent in the cavity R. The lower anterior lateral opening (B) is 8 mm. in diameter, slightly ovoid. It runs straight to the cavity slightly forwards, dilating inwardly. The first part of the tube is formed by an inner projection of the skin of the head merging into softer tissue within, which joins the margin of the ethmoidal cartilage, through the lateral flange of which the tube continues to the central cavity. The tube B runs below the lateral margin of the parafrontal-antorbital series of bones and above the head of the columnar lateral process of the ectethmoid (38). It had been suggested by Stensiö that in some forms the narial tubes may have passed through foramina in the antorbitals. His later withdrawal of that view is more in line with what I observe in *Latimeria*. The lower tube is about 35 mm. in length.

The upper tube (C) is about 25 mm. removed from the lower. The aperture and the tube are of slightly smaller diameter and shorter than B. The tube is of construction similar to the lower, but runs more obliquely forwards, through a tube in the ethmoidal flange as for B.

Running longitudinally along the flange of the anterior chondrocranium is a narrow tube (J) which I take to be the canal for the ophthalmic branch of the V and probably also the VII nerve. This canal opens into the upper narial tube (C) close to the median capsule (R), is continued between the tubes B and C, and appears finally to dip into the olfactory capsule. I am not certain of the latter as the cartilage in that region had been pulled about.

This system is difficult to interpret. Whether or not it has any affinity with the medio-dorsal olfactory system of Cyclostomes I am not prepared to say. That it now has no ventral connection, and shows no sign of ever having had any, with any part of the brain is certain. It is probably significant that the only part of the ethmo-rostral area not covered by bones is the roof of this ethmoidal cavity (R). There are no flaps to control or prevent the entry of water, and the membranous lining of the tubes does not appear to have been erectile or ciliate. Water would thus have free

entry through the tubes into the sinus R. When the fish moves forwards through the water, a current will pass through the rostral aperture (A), through the cavity, and out at the sides *via* tubes B and C. When the fish turns to one side, a contra-current will tend to flow through this



TEXT-FIG. 6.—*Latimeria chalumnae* Smith. Dorsal view of rostro-nasal area. The ethmoidal cartilage is cut away above the level of the narial openings. Cartilage shown by parallel line shading. Bones are outlined by cross-hatched double fine lines. The olfactory capsule is outlined by dots. The line represents 1 cm. For explanation see Folder-page I at end.

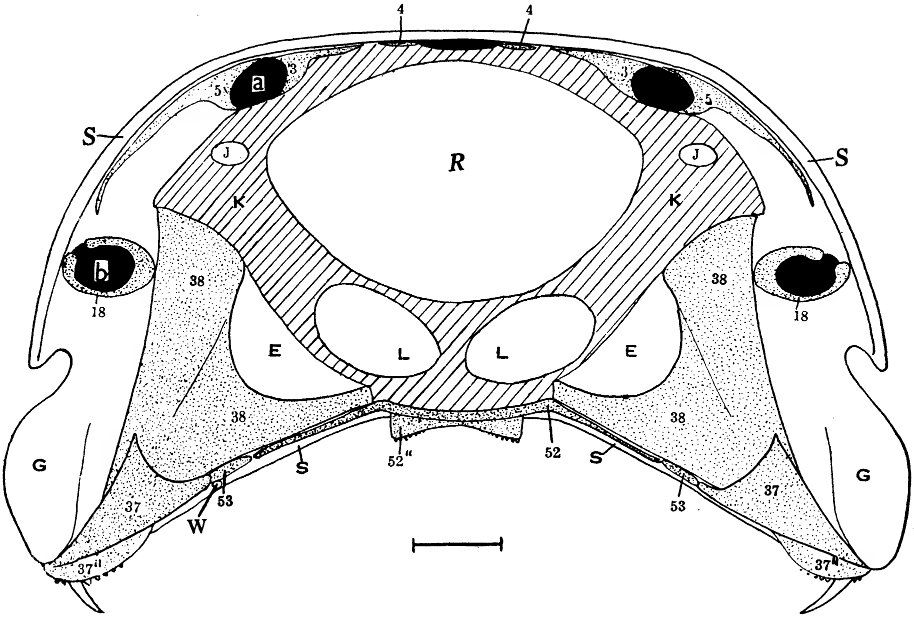
system. The whole may represent some form of sensory system, but exactly what may possibly not be decided until embryonic stadia become available for study.

The olfactory capsules (E) lie on each side of the snout, with anterior edge 10 mm. from the front margin of the rostrum. Each is a sac about 25–30 mm. longitudinal diameter, 25 mm. in width and about 25 mm. in height. Each is separated from its antimere by about 12 mm. across the upper surface of the parasphenoid (52).

The floor, the outer, and part of the hinder wall of each sac rests against the inner surface of the ectethmoid (38). The anterior face of the sac is

supported by the rostro-nasal (18), which rests against the anterior margin of the columnar process of 38. The inner hinder wall is in the rostral cartilage. There is a foramen above and behind communicating with the optic lobe of the brain (L) for entry of nerve I.

In so far as I can determine there is no external opening on any part of the head which communicates directly with these capsules. The lining membrane in the left capsule was in a bad state, being rather noisome and



TEXT-FIG. 7.—*Latimeria chalumnae* Smith. Transverse section of head 40 mm. from snout tip (see text-fig. 15). Cartilage shown by parallel line shading. Sensory canals black. Bone sections dotted. The line represents 1 cm. For explanation see Folder-page I at end.

partly glutinous and oily. It appeared in some degree to have been convoluted. Although the tissues had been rudely torn, I was able to trace a tubular structure of relatively fine tissue emerging from the capsule (E) through an aperture which exists above the lateral limb of the rostro-nasal (18), where it rests against the face of the outer column of the ectethmoid (38). This aperture is shown in text-fig. 11. The tubular structure runs outwards and laterally along the upper surface of the lateral limb of 18. What it is I could not with certainty determine. It may have been an anterior branch (optic-nasal) of the carotid artery.

Rostral Tentacle (Cirrus) (D).

(Plates XI and XII; text-figs. 6 and 10.)

On each side of the rostrum is a flattened truncated conical cirrus or tentacle (D). Each is set in an oval base. The tentacle is 9 mm. in length and 4 mm. in width at the base. It is apparently imperforate. I can find no connection between this and any internal structure. It occupies much the position of the nasal cirrus found at the posterior margin of the oro-nasal groove in certain Selachians.

Structure of the Mandibulary Rami.

(Plates IX, XI, XIV, XV, XXI, XXII, and XXV; text-figs. 5, 8, 9, 11, and 13.)

The mandibulary rami are composite in structure, and have a lateral profile length of 250 mm. The quadrate articulation is anteriorly 190 mm. from the tip of the lower jaw in profile.

The outer surface of each ramus is formed chiefly by, posteriorly, an elongate angular (29) which covers the outer lower margin, and anteriorly by a similar but shorter splenial (30) which extends almost to the symphysis. Each of these structures is externally convex, fairly stout with an interior cartilaginous lining which, in the case of the angular, lines the adductor fossa (O).

Anteriorly, supero-internally, is the dentary (44) which appears to be, at least superficially, partly cartilaginous. Originating 50 mm. from the symphysis of the lower jaw is an elongate plate with anteriorly strongly convex edge, the articular-prearticular plate (43) which forms the inner, almost vertical surface of the lower jaw. The lateral face of the articular-prearticular plate (in the adductor fossa) is lined with cartilage.

On the inner hinder edge of the dentary (44) is the small precoronoid (40). Posteriorly is the elevated coronoid (41) whose inner surface dentition is extremely feeble. 25 mm. in profile behind the symphysis of the lower jaw there originates a stout external dermal labial fold (X) which extends, thickens, and broadens posteriorly, rising towards the coronoid (41), where a fossa on the outer side of its hinder margin receives the ligamental attachment from the inner face of the hind portion of the pseudo-maxillarial fold (G).

Chiefly between the angular and the prearticular plate (43) lies the extensive adductor fossa (O), which extends from in advance of the pre-coronoid (40) to almost beneath the quadrate articulation, having an approximate length of 140 mm. Its depth is approximately 18 mm. immediately in advance of the quadrate articulation, and it tapers to an

apex anteriorly. The fossa is roofed anteriorly by the inner fold of the labial cartilage.

Immediately anterior to the quadrate articulation the ramus of the lower jaw is 33 mm. in cross-section and 40 mm. in height. The lower surface of the lower jaws is covered almost entirely by the two very large and heavy gular plates (31), that on the left overlapping the right along the mid-line. These plates extend posteriorly to the level of the hind margin of the articular (32) and anteriorly to within 35 mm. of the symphysis, with a slight groove between the anterior limbs. For the greater part of the lower surface the gular plates overlap the lower margin of the angular (29). Anteriorly the gulars curve sharply inwards to their apices, so that between their anterior margins and the hinder margins of the splenials (30) is left a broad arrow-shaped area of thick folded skin which invests the anterior bevelling of the gulars. Just beneath the symphysis of the lower jaw originating 10 mm. from the apex is a fairly deep medio-longitudinal groove 6 mm. in length.

The articular (32) is comparatively short, at the maximum 60 mm. in length, and forms a bridge posteriorly between the angular and the articular plate. Time has not permitted me to ascertain the exact boundaries of the articular.

Angular (29).

(Plates IX, XI, XIV, XV, XXI, and XXV; text-figs. 5, 8, 9, and 13.)

The externally convex angular (of the left side) is 170 mm. in length and 40 mm. greatest depth, which occurs midway along its length. It is a massive bone which forms the main foundation of the hinder part of the mandibular~~y~~ structure, and is 14 mm. in average thickness. The lower exposed margin of the bone is almost straight, and rises posteriorly and anteriorly to sharply rounded ends. The upper edge is undulate, rising from the anterior edge with gentle anterior concavity to a convex elevation midway where the bone is deepest. Thereafter the margin slopes downwards with gentle concavity, to meet the hinder end with a very slight, sharp convexity immediately below the outer ridge of the quadrate (34).

All the upper and most of the outer surface of the angular is smooth, with very fine radial striae and minute pits, but it bears no ornamentation in the form of tubercles, nor is there any indication that those were once present. There is little doubt that the whole upper length of the bone, with the exception of the posterior oblique entry tube of the mandibular canal (*e*), is solid. The lower margin of the angular bears the mandibular canal (*e*) (text-figs. 5 and 9), and above the line of the canal are several grooves and pits roofed by membrane. The lower margin of the bone is fairly elaborately sculptured. On the hinder lower surface the posterior

extension of the mandibular canal merges into a superficial groove, deep anteriorly, becoming shallower posteriorly, eventually rising to the surface of the bone. This groove is for its entire length roofed by strong membrane which merges into the skin behind.

The angular of the right side is 160 mm. in length and of maximum depth 38 mm. It is almost exactly similar to the left angular, except that there is medially a fairly large pit-groove structure which has a dorsal branch. The external surface of the angular appears to consist of ganoin. The centre of radiation appears to be exactly midway over the upper portion of the mandibular canal (*e*).

The upper portion of the angular is expanded across the mandible immediately in advance of the base of the quadrate (34), and forms the hinder face of the anterior margin of the quadrate articulation facet (text-fig. 13). Posterior to the quadrate the angular continues backward (text-fig. 13) for 46 mm., curving inwards beneath the skin, becoming apically fairly acute and progressively thinner. In this portion it forms the base upon which the relatively short articular (32) rests.

Splenial (30).

(Plates IX, XI, XIV, XV, XXI, and XXV; text-fig. 5.)

The left splenial is 73 mm. in length and 19 mm. in greatest external width. It lies beneath the dentary (44), and is similar in structure to the angular (29) with smooth outer surface above, bearing fine radiating grooves and pits.

The mandibulary canal (*e*) runs just below the mid-line of the splenial to near the anterior end. There it rises to emerge through the middle of the apex of the splenial, travelling thence to the symphysis. It appears to communicate across the symphysis, but time has not permitted the necessary dissection. The lower margin of the angular has, especially anteriorly, fairly numerous grooves roofed by membrane. There is a deep antero-exterior excavation with a membranous roof which is a dorsal expansion from the canal.

The centre of radiation appears to be located on the canal nearer the anterior than the posterior margin of the bone.

Articular (32).

(Text-figs. 8 and 13.)

Owing to the lack of time it has not been possible to make a complete dissection so as to expose the full extent of the articular. It is, however, a relatively small structure apparently confined to the post-quadrate portion of the mandible. The pre-quadrate rampart of the articulation

is almost certainly formed by the angular. The hind face and probably part of the floor of the articulation fossa for the quadrate are formed by the articular. The greatest length of the articular would appear to be 42 mm. and its greatest width about 21 mm. It is thickest anteriorly, its width and height tapering posteriorly to a blunted rounded hinder apex approximately 12 mm. in height, with inner face sloping inwards and downwards.

In the upper surface immediately in advance of the hinder apex is the cartilage-lined facet for articulation with the foot of the symplectic (39). This facet may clearly be seen in the inner portion of the articular of a specimen of *Diplocercides kayseri* (v. Koenen) figured by Stensiö ("Devonian Coelacanthids of Germany," Kungl. Sven. Vet. Hand., 1937, 3rd ser., vol. xvi, No. 4, text-fig. 18, pls. i and iii). It shows above the inner articular plate behind the quadrate articulation. Stensiö gives (*ibid.*, p. 15, text-fig. 7) a drawing presumably from the fossilised remains shown in pl. iii, but has apparently not regarded this facet as being of any significance, since he does not show it in the text-figure. It is likely that this facet will be found on the inner hinder face of the articular of all Coelacanthids.

Gular (31).

(Plates IX, XI, XIII, XIV, XV, XXI, and XXV; text-figs. 5 and 9.)

The gulars are 225 mm. in total length and 70 mm. maximum width, which occurs about the middle of their length. The outer surface of each gular is ventrally convex, the transverse convexity having a faint broad anterior ridge, the longitudinal convexity being comparatively slight.

The plates are not more than 4 mm. in thickness and lie immediately beneath the skin of the floor of the mouth. In general shape each gular is more or less fusiform but with each apex pushed over towards the inside, anteriorly more than posteriorly. The inner margin runs almost straight from the apex posteriorly, then curves out a distance of 15 mm. to the posterior apex. From the posterior apex the outer margin is broadly convex, and runs in a gentle curve to the widest part of the bone. Thereafter the gular narrows anteriorly to about 35 mm. behind the apex, when the margin curves inward to the apex forming an anterior concavity.

The left gular overlaps the right for about 4 or 5 mm. for three-quarters of the length along the middle portion. Anteriorly the inner margins are separated 2 mm. apart for 22 mm. of their length. The outer surface of each gular is hard and fairly smooth, consisting apparently of ganoin. The surface bears very fine reticulate grooves and a dense system of minute pits. The grooves lie chiefly anteriorly along the outer margin and postero-apically. The tiny pits cover most of the central (inner) portion of the bone.

The left gular shows no trace of tubercle ornamentation. There are in its surface several large deep excavations on the anterior third and towards the centre, all roofed by membrane. These are not definite "pit-lines," but communicate with deep and extensive sensory cavities within the bone. I cannot trace any other sensory organs in either gular.

The right gular differs from the left solely in possessing two isolated pairs of small tubercles on the lower surface, and in having the roofed pits slightly nearer the outer margin than those on the left. The outer margins of the gulars are trenchant. They appear to be much thicker anteriorly.

Coronoid.

(Plate XXI; text-figs. 8, 9, 11, and 13.)

The coronoid is situated with the anterior margin 100 mm. from the tip of the lower jaw. It is somewhat trapeziform, roughly in the form of a truncated triangle with undulate base and sides. The structure is 40 mm. in height, 65 mm. in length, and but 2–3 mm. thick at the thickest point, which occurs at the lowest anterior portion (left coronoid).

On the anterior lower part of the face is a granulate plate, more or less hastate in outline, with apex posterior, 37 mm. in length and 14 mm. in height. Above this plate the inner face of the coronoid bears small blunt tubercles, slightly larger posteriorly. The main structure is hard, apparently well ossified, and may even bear ganoin on its inner face.

In transverse section the coronoid slopes inwards and downwards, the interior face being concave above and convex below (text-fig. 9). The basal margin of the coronoid articulates with the upper edge of the articular-prearticular plate (43). The upper edge of the structure is gently convex and firmly attached to stout connective tissue. The pseudo-maxillarial fold (G) is joined into a posterior fossa in the hind margin of the elevated expanded hind portion of the lateral labial fold, which ends beneath the anterior corner of the upper portion of the coronoid.

The coronoids probably add very considerably to the strength of the jaws. They would effectively prevent any lateral play between the upper and lower jaw when the mouth is closed or almost closed. The typical raptorial nature of the dentition, and the obvious provision for very large jaw muscles, would indicate that prey once seized could never escape.

Mouth.

(Plates I, X, XI, XII, XIV, XV, XXI, XXII, and XXV; text-figs. 5, 7, 8, 9, 10, 11, 12, 13, 15, 16, and 17.)

The mouth is large, terminal, horizontal, with lower jaw projecting slightly. The gape extends to below the hind margin of the eye, 160 mm.

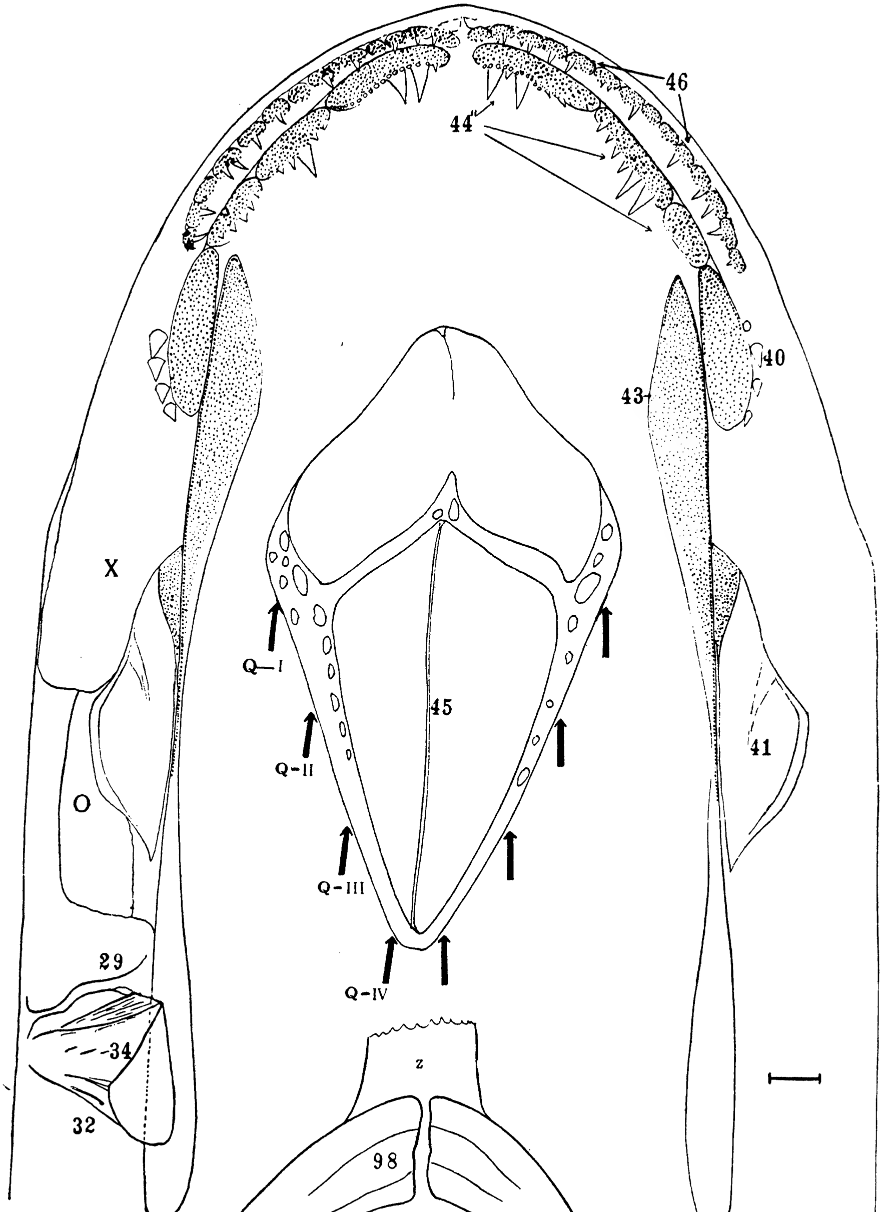
from the snout tip measured obliquely. Width at hind angle 160 mm. The dentition is raptorial and fairly powerful. The most powerful dentigerous structures are the plates held by or upon the prevomers (53″), the palatines (37″), the ectopterygoids (36), the dentaries (44″), and the precoronoids (40). The teeth are all conical, ranging from small, blunted basal granules to large prominent tusks. Mostly each dental plate is composed of the coalesced bases of small or moderate teeth, which increase in size towards the mid-portion of the inner margin of the plate, where usually two large sharp tusks form the chief dentition. Only in the case of the hinder part of the ectopterygoid do the teeth appear to be implanted directly in that bone. The dental plates are in some cases superficial only, being held by the thick skin of the mouth (90, 91, 46).

There is evidence that replacement of teeth is successional, since in several of the dental plates where a large tusk has obviously recently been lost, a similar but smaller retrorsely depressible tooth appears to be moving upwards in replacement.

Lower Jaw.

(Plates IX, X, XI, XII, XIII, XIV, XV, XXI, XXII, and XXV; text-figs. 5, 8, 9, and 11.)

The lower jaw has massive rami, the gular plates (31) providing additional strength. On the upper external surface of the dentaries is set in the skin a series of twenty-seven small dental plates (46), which represent the anterior portion of the labial fold. On the left dentary are thirteen plates, on the right fourteen. The bases of the plates are contiguous, with a break at the symphysis. The plates are oval, 5–6 mm. in width and about 3–4 mm. in average depth, and are very firmly fixed in the extremely tough skin of the "lips." Each plate is composed of close-set, basally coalesced small conical teeth 1–3 mm. in length. Of the plates on the left dentary, nine bear in addition posteriorly a larger curved caniniform tooth about 4 mm. in length, one bears two such teeth, the remaining two having only small teeth. On the right dentary eight plates bear each a single larger tooth, while four bear pairs of larger teeth, the remaining two having only small teeth (text-fig. 8). Immediately internal to these "labial" teeth, and running behind them, is on each side a system of three exactly similar, but much enlarged, plates (44″). On each side of the symphysis is the anterior plate of the dentary. The length is 24 mm. and transverse width about 6 mm., with outer margin convex. The basal teeth are externally fine, somewhat blunted. They increase in size inwards, finally forming a posterior medial ring, the apex of which stands about 6 mm. above the lower margin of the external edge of the base. Behind



TEXT-FIG. 8.—*Latimeria chalumnae* Smith. Dorsal view of lower jaw showing quadrate articulation. Small teeth shown by dots which are not acourate as to number. The position of the tuberculate copula is approximate only. The large arrows behind the copula show points of attachment of the branchial arches. The line represents 1 cm. For explanation see Folder-page I at end.

this rampart, slightly to the inner side, are inserted two large tusks, each about 9 mm. in free length, which are directed obliquely upwards and inwards. The second pair of plates, the medial supradentaries, originate 33 mm. radially on each side from the symphysis. The left plate is 20 mm. in length and 5–6 mm. in transverse width. Behind the central rampart are inserted five larger teeth, the central being much the largest, the outer two pairs being graduated smaller. The right plate is 23 mm. in length and 5–6 mm. in width. There are six enlarged teeth along the hinder margin. The posterior two are large tusks, directed inwards and upwards, while the remaining four are graduated smaller anteriorly. The outer posterior pair of supradentaries is the smallest. Each originates 53 mm. radially from symphysis, is about 16 mm. in length and about 6 mm. in width. The right plate has only small teeth. That on the left has an inner series of five moderate, stout, conical teeth, the centre one being the largest, the outer graduated shorter, all directed inwards and upwards.

The marginal dentition is completed by that on the precoronoids (40), which originate radially about 70 mm. from the symphysis, where the transverse width of the lower jaw is about 120 mm. On the inner face of each precoronoid is an oval basal plate, 30 mm. in length and 14 mm. maximum height, which bears close-set small denticles. Above and external to the hinder upper edge of the denticulate plate are large conical teeth in a single series. On the left side there are four large tusks, the anterior the largest, directed obliquely backwards, the hinder teeth graduated rather smaller and increasingly more retrorse. On the right precoronoid are also four somewhat smaller teeth, the anterior almost vertical, the posterior three directed backwards, the hindmost almost prone.

Still further posteriorly lie the large more or less trapeziform coronoids (41), which have been described elsewhere.

The inner surface of the lower jaw is formed by an elongate denticulate plate with subvertical surface, the articular-prearticular plate (43). The anterior end is rounded and originates below the hind end of the posterior supradentary. The plate is 180 mm. in length and 40 mm. average depth, with a convexity below the basal denticulate plate of the coronoid. The plate extends backwards beyond the quadrate articulation, to the anterior margin of the articulation facet for the symplectic (39). The anterior part of the face of the plate (43) is dentate, the denticles along the anterior and upper margins being the greatest. Posteriorly and inferiorly the denticles become smaller, until finally, 90–100 mm. from the anterior end, they merge into fine striations which become obsolete posteriorly. The posterior part of the face of the plate is almost quite smooth.

On the floor of the mouth only part of the original skin has been left.

Anteriorly are a few small dermal plates bearing denticles resembling those on the copula (45). On the floor of the mouth is the tuberculate copula. This structure had been removed before I saw the specimen, and the severed skin on the floor of the mouth does not assist very much in orientating the copula. I can only suppose the tubercles on the copula to have opposed the parasphenoid plate (52″), since it fits fairly well against that. The copula is shown in text-fig. 8, but its position there is only an approximation.

Copula (45).

(Plates XXIII and XXIV; text-figs. 8 and 9.)

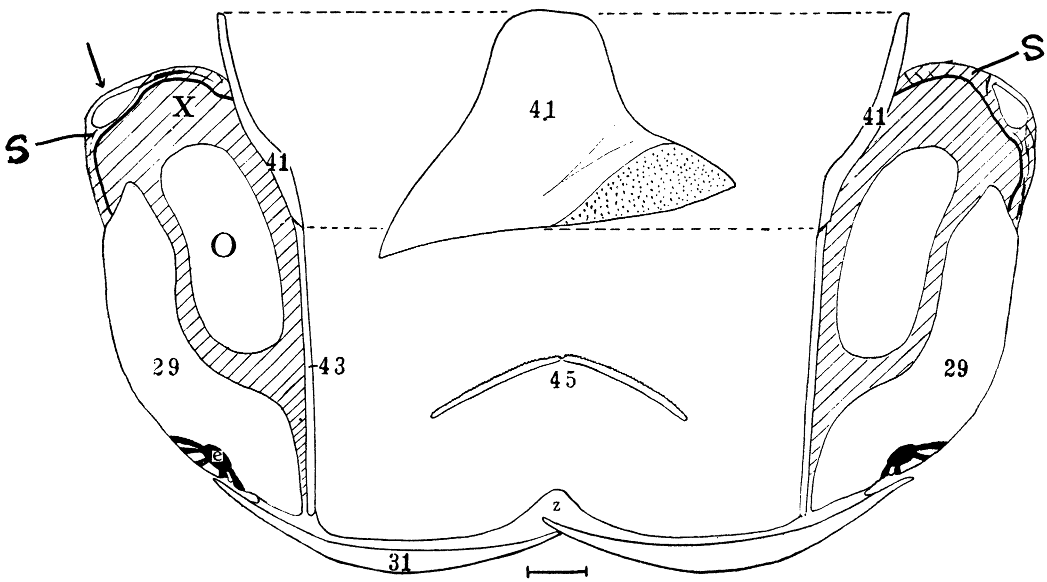
The copula is a composite ossification, consisting chiefly of a laminate superiorly convex tuberculate roof of four fused plates. It was stated to have had the appearance of a free "tongue" in the floor of the mouth. The total length of the structure is 118 mm. and its maximum breadth is 58 mm.

The upper surface is formed by the fusion of two pairs of plates. The anterior pair form a blunt arrow-head with median suture of about 30 mm. in longitudinal length. The hinder pair with median suture form a hastate hind limb whose apex fits into the recess in the "arrow-head." The hind plates are each about 80 mm. in length and 28 mm. in width at the widest part, which occurs anteriorly. The whole surface is hastate, with apex posterior. The four plates are densely covered with somewhat elongated tubercles in more or less regular radiating rows. Those on the anterior pair radiate out in regular rows from the apex, while on the posterior plates the tubercles radiate out in all directions from an area midway along the inner margin of each plate. Posteriorly on the structure the tubercles become so close-set as to resemble longitudinal striae. The four plates appear to have originated from scale-like entities. The margins of the plates are bound to thick skin such as remains marginally on the floor of the mouth. On this skin, marginal from the anterior edge of the hinder plates, are small dentate or granulate plates of irregular size and shape, which are similar to those on the floor of the mouth. They are patently but modified scales.

Transversely the copula is arched, the sides sloping at about 15° downwards from the horizontal (text-fig. 9). In longitudinal section the copula is almost straight.

As mentioned previously, the copula had been removed from the buccal cavity during mounting, and the taxidermist cannot give much information about it, except that it was visible from the front of the mouth, that it was part of the gills, and that the gill-arches were attached to its lower surface. I judge that the structure was set up in the mouth sloping upwards and

backwards at an angle of about 30° to the horizontal, so as to present a surface to articulate with the parasphenoid plate (52″). Below the angular suture between the posterior and anterior plates is a light, ossified, more or less pyramidal box-like structure, either hollow or very poro-cancellate within. It probably represents a basi-hyal or glosso-hyal. The hollow ossification has been enveloped in cartilage. It is 48 mm. in length, 44 mm. in width, and 22 mm. in height. It bears a circular depression, 21 mm. in diameter and about 8 mm. in depth, on its hinder face. I take this to



TEXT-FIG. 9.—*Latimeria chalumnae* Smith. Transverse section of lower jaw 130 mm. from symphysis. Cartilage shown by oblique line shading. Dentate area dotted. Central (above) is view of coronoid from within the jaw. The arrow shows the fossa for attachment of pseudo-maxillarial fold (G). The position of the copula is approximate only. The line represents 1 cm. For explanation see Folder-page I at end.

be a facet for articulation of possibly a hypobasibranchial. Below this depression is a transverse rectangular facet, 28 mm. in width and 4–5 mm. in height, which is probably the articulation facet for the head of the uro-hyal. On the anterior face of the hollow ossification is a median cartilaginous ridge which bifurcates anteriorly, *i.e.* just below the roof of the copula, into two dilated rounded branches. On each side is thus formed a moderate fossa against the median ridge, which may be the points of articulation of the anterior inner faces of the cerato-hyals. Very similar, in fact almost identical, is the structure shown by Nielsen (Prelim. Rem. Trias. Fishes, East Greenland, Medd. Grøn., 1936, Bd. 112, Nr. 3, pp. 33–34, fig. 16) in a large unidentified Coelacanthid from East Greenland.

I cannot find any signs of the wide longitudinal canal stated by Nielsen to be present in his material.

Along the margins of the lower cartilaginous backing of the hinder plates of the copula are clearly to be seen the points to which on each side four cartilaginous structures, presumably gill-arches, were attached. The number is certainly four and not five. I should judge that they were superiorly attached to the copula, and probably bound more closely together by attachment to a rod-like, possibly entirely cartilaginous, basibranchial, whose head would articulate in the circular fossa in the hind face of the basi-hyal.

No traces of a cerato-hyal remain in the fish.

Upper Jaw.

(Plates XI, XII, XIV, XV, XXI, XXII, XXV, and XXVII; text-figs. 5, 7, 10, 11, 12, 15, 16, and 17.)

The most striking feature of the upper jaw is the absence of maxillae and of premaxillae. The external appearance of the upper jaw suggests that maxillaries are present. This is due to the presence of a thickened fold of skin here termed pseudo-maxillarial labial fold (G), which originates on the outer face of the base of the ectethmoid (38), and extends along beneath the lower edge of the suborbital (48). The hind end of the structure, from within its rounded apex, is connected within a fossa in the hinder upper portion of the cartilaginous lower labial fold (X) (see arrow, text-fig. 9). Externally this structure resembles a conventional maxilla very closely. Its presence suggests that there has never been a "loss" of a maxilla in any ancestral form, but rather that in that ancestral form the structure of maxillarial homology failed to develop by ossification. In its hinder third this fold is 24 mm. in depth and 8 mm. in average thickness. It is extremely tough, being enclosed outside, below, and within by extremely hard skin, though it shows no sign of ossification. The central portion in a section has a structure similar to that shown for the skin of the cheek in Plate XLIV.

Most of the teeth in the upper jaw are borne by dermal plates. In some cases these are set in the skin, in others they appear to be fused to the lower surface of the palatal bones. Only in the hinder part of the ectopterygoid are there any teeth set directly in a palatal ossification.

The comparatively slight vertical bones in the rostrum (20, 21, and 22) do not resemble either a developing or an obsolescent premaxillary. The rostral dental plates (90) are purely superficial structures without definite relationship to the rostrals (20–22), except that they lie about 4–5 mm. beneath them in the skin. The total width of the rostral projec-

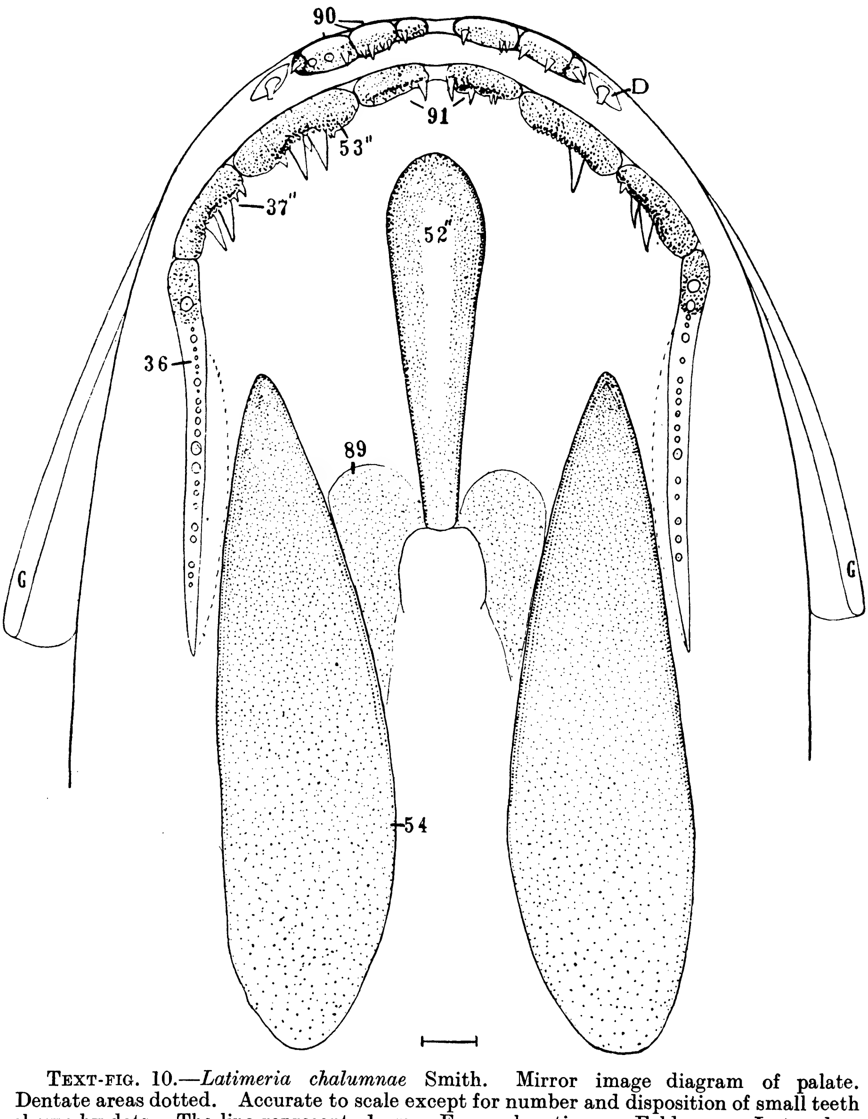
tion is 55 mm. The lower surface is divided into two lateral segments by a moderate groove 5 mm. in width. On the left section are four dental plates. Externally is a small stud-like plate with a moderate conical tooth centrally and a smaller one anteriorly. The next plate is largest, 10 mm. in length, and bears three conical teeth which are directed downwards, radiating slightly. The second lateral tooth is the largest, 4·5 mm. in length. The plate is smooth anteriorly with a few basal denticles. The middle plate is 8 mm. in length and bears four teeth smaller than those on the outer plate, but is otherwise of similar structure. The inmost plate is only 6 mm. in length and bears three small conical teeth directed obliquely backwards. On the right section of the rostrum also are three plates. The outer is but 4 mm. in diameter and bears one conical tooth, 5 mm. in length, directed outwards and backwards. The right median plate is 9 mm. in length and bears two conical teeth directed almost horizontally inwards. The inner plate is 13 mm. in length and has two moderate conical teeth on its lateral portion, a larger tooth on the opposite side and a smaller tooth midway between, all directed obliquely inwards. All plates are smooth anteriorly, with blunted denticles at the bases of the larger teeth. Many of the exterior denticles are merely tubercles exactly similar to those on the scales.

5–6 mm. behind the rostrals is the anterior part of the marginal dentition of the upper jaw. At the apex are two dental plates, 4 mm. apart across the mid-line, which are termed "post-rostrals" (91). These plates bear no relation to any palatal ossification. They are set in the skin of the mouth inward from, and slightly anterior to, the prevomers. Each is 14 mm. in length and about 5 mm. average breadth. On the right post-rostral are four fairly large, slender conical teeth directed almost horizontally backwards. The inner (4 mm.) is largest, the outer graduated smaller. The left postrostral bears one inner similar tooth (4 mm.), and more laterally are five smaller teeth, all directed inwards.

The dermal plates of the prevomers (53″) are the largest in the upper jaw. They lie immediately outside the postrostrals. The right plate is 24 mm. in length and 6 mm. in width; the left 27 mm. in length and 7 mm. in width. On the right plate is one stout tusk, 12 mm. in length, inserted behind a rampart of stout low conical teeth. There had evidently been two such teeth, since the socket of another is visible, in which anteriorly a retrorse smaller tooth is clearly in process of upward succession. The left plate of the prevomer bears two large tusks (11 mm.) directed obliquely inwards. Between them and outside them are somewhat smaller similar teeth, all inserted behind a stout rampart of low conical teeth.

The palatine plates (37″) lie postero-externally to the prevomers. The right plate is 21 mm. in length, the left 20 mm. Each bears two large

tusks (9 mm.) directed backwards and inwards, inserted behind a rampart of stout low conical teeth, one or two of which anteriorly are enlarged.



TEXT-FIG. 10.—*Latimeria chalumnae* Smith. Mirror image diagram of palate. Dentate areas dotted. Accurate to scale except for number and disposition of small teeth shown by dots. The line represents 1 cm. For explanation see Folder-page I at end.

The marginal dentition is completed by the ectopterygoids (36), which curve inwards from their origin behind the palatine plates and thereafter run straight along the lateral face of the pterygoids. Anteriorly each

bears a dermal plate. The right dermal plate bears two large fang-like conical teeth, the anterior the larger, both directed somewhat backwards, while the left bears a single large tusk (10 mm.) directed inwards. Behind the plate in each ectopterygoid is a single series of conical fang-like teeth of various sizes, apparently implanted directly in sockets in the bone itself. In the right ectopterygoid, behind the dermal plate, are anteriorly two small teeth, then one somewhat larger. There follow in succession six smaller teeth, a large tusk, two small teeth, and finally three moderate fangs. The left ectopterygoid has in its succession of teeth anteriorly a small canine, then a moderate fang-like tooth, four rather small teeth, another like the second, followed by a mere point, then four small fangs with two heavy tusks (8 and 7 mm. in length) behind. These are followed by three small teeth, then two somewhat larger, and finally by a posterior group of three smaller teeth. Each ectopterygoid is approximately 70 mm. in length within the jaw.

The parasphenoid dermal plate (52″) originates 25 mm. behind the apex of the rostrum, and is about 70 mm. in length. It is more or less spatulate, anteriorly dilated, the maximum width 19 mm., occurring in the anterior third of its length. Posteriorly it is 6–7 mm. in width. The plate is concave beneath, along the median line. Its cross-section at various points may be seen in text-fig. 12. The plate is densely covered with granulo-conical teeth which diminish inwardly and posteriorly. Those round the anterior margin are enlarged, and robustly conical and sharp, forming a raised edge. The hinder granules are feeble.

The entopterygoid plates (54) are large. They are fairly thin and approximately triangular in shape, being set on the inner face of chiefly the anterior lobe of the pterygoid (33), thus facing inwards and downwards. (Text-fig. 10 shows their vertical projection.) They are about 130 mm. in length and about 45 mm. in oblique height at the maximum. The hind margin of the plate extends about 200 mm. behind the apex of the rostrum, to above about the middle of the quadrate (34). The whole outer surface is firmly adnate to the pterygoids. The dentition is feeble. Anteriorly along the margins are small blunted conical teeth in one or two series. Inwards from these are bluntly rounded denticles, anteriorly fairly close-set, diminishing in size and density of setting posteriorly. The posterior lobe of the plate is almost smooth.

Between the entopterygoids and the parasphenoidal plate is a dentate area of the skin, pointed posteriorly, with rounded anterior margin, about 40 mm. in length and 15 mm. maximum width, with margins abutting against the entopterygoid and the parasphenoidal plate. These areas are but feebly ossified if at all, the rather granular close-set teeth being apparently merely dermal denticles in the rather stout skin connecting

the pterygoid with the parasphenoid ventral face. I name these for convenience suprapterygoid (89) areas.

Between the dentigerous structures the roof of the mouth consists of extremely tough leathery skin, about 1·5 mm. in thickness, of very smooth surface. There is no sign of any internal narial opening. Between the pterygoids, behind the parasphenoidal plate, the hind margin of the parasphenoid and all of the ventral (mouth-roof) structures had been removed when the fish was mounted.

Structure of the Dental Plates and of Teeth.

(Plate XXXII.)

This has been investigated by taking sections of the second (from without) rostral dental plate and of one of the teeth it holds.

The plate is rounded anteriorly, the front surface being almost edentate and fairly smooth. The hinder portion of the plate embedded in skin and cartilage is produced into a sharp ridge. The body of the plate is densely ossified, and marginally very solid. The teeth are implanted in fairly deep sockets, with rounded bottoms. Chiefly above each tooth, but all along the central core of the plate, are irregular sinuses, apparently interconnected, containing pulp or vascular tissue. The lowest of these communicates directly with the pulp-cavity in the tooth, while the most dorsal is right in the upper surface of the plate. This excavated portion is not of a spongy nature, the bony walls between the sinuses being quite solid. The whole suggests origin from the cosmoid type of scale.

The teeth are almost certainly derived from tubercles such as are present upon the body scales. On the front margin of the rostral plates are present all stadia transitional between low rounded tubercle and elongate conical tooth. In Plate XXXII a small tubercle may be seen in section on the front margin of the plate anterior to the main tooth.

The teeth themselves are hollow almost to the apex, and the pulp-cavity is rather large. The tooth is actually a hollow cone with a more or less hemispherical base deeply embedded in the body of the dental plate. The base beds on to and opens into the lowest irregular sinus of the body of the plate.

ylinder A transverse section of the tooth is a ~~hollow cone~~. In fine section the body of the tooth has a radial structure, but no tubuli can with certainty be distinguished. The outer layer of enamel, except at the apex of the tooth, is rather thin. Under the polarising microscope the dentine shows slight birefringence with somewhat undulose extinction, suggestive of strain rather than of crystalline structure.

The elongate spines on the dermal plates of the inner surface of the

hyo-mandibulary capsule (Plate XXX) are of structure similar to that of the teeth. They are rather more slender than the teeth, and the pulp-cavity is of relatively smaller diameter. The rostral (and jaw) teeth appear to have developed by extension of the upper portion of the tubercle, the buccal denticles by prolongation of the ends of the tubercles.

Palato-pterygo-quadrate System.

(Plates XXI, XXII, XXV, XXVII, and XXVIII; text-figs. 6, 7, 8, 11, 13, 16, 17, and 18.)

This complex is massive, well ossified, and forms the principal foundation of the skull.

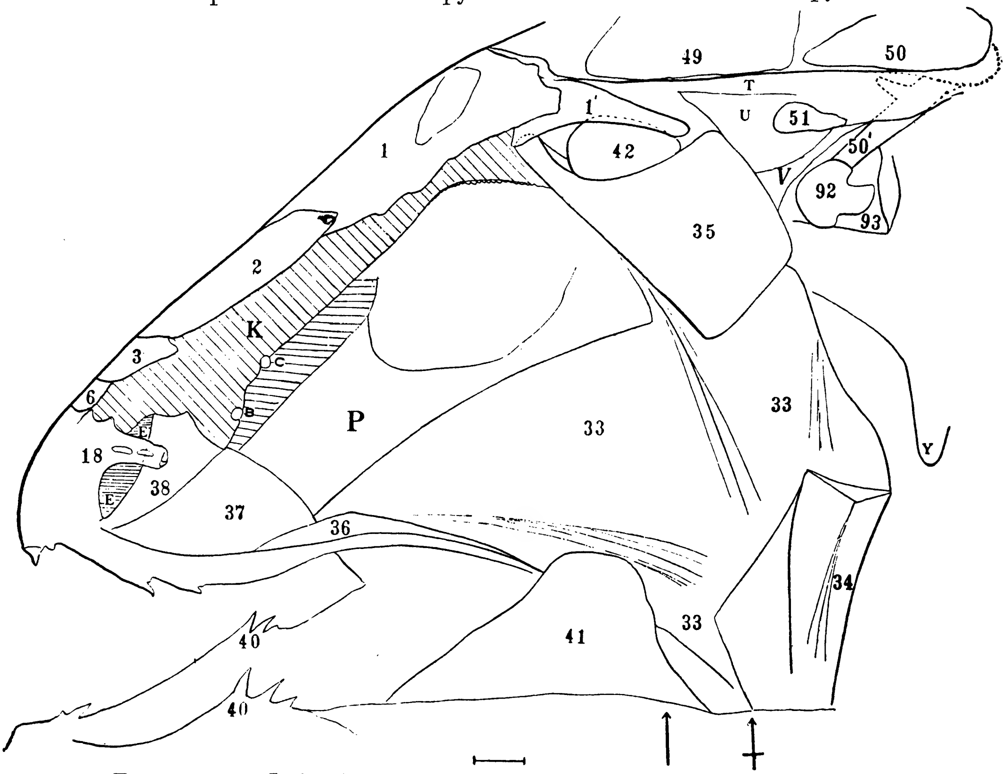
Quadrate (34).

(Plates XXI, XXV, and XXVIII; text-figs. 8, 11, 13, and 18.)

The quadrate articulation occurs 185 mm. behind the tip of the lower jaw. The lower portion of the quadrate is typically expanded, and the condylous extremity is externally cartilaginous. The main limb of the quadrate is an inverted triangular pyramid of rather small base. The greatest height of the quadrate is 76 mm. The triangular upper surface is 26 mm. in length and 11 mm. in width (transverse). The hinder surface of the column slopes slightly backwards as a slight concavity. The anterior ridge of the triangular column is expanded into a ventrally wider laminate limb. The total width of the quadrate half-way up its length is 34 mm., the laminate expansion being 20 mm. wide at that point. On the outer upper face of the quadrate is a fairly sharp dorso-ventral ridge for half the columnar length, corresponding with one angle of the sectional triangle. The inner face of the quadrate appears to be gently rounded and lies mostly just external to the plane of the prearticular (43). The triangular dorsal face of the quadrate column is soft and porous and had obviously been connected by cartilage with the hindmost outer surface of the pterygoid (33). The inner face of the quadrate fits exactly on, and is marginally at least closely adhesive to, the exactly similar conformation of that portion of the outer face of the pterygoid, *i.e.* the lower hinder portion of the pterygoid (33). The quadrate and that portion of the pterygoid are very firmly bound indeed, so that it would almost appear as if the bones had fused within at least part of the contiguous surfaces. It appears that the cartilaginous attachment between the quadrate and the pterygoid may have a dorsal extension attached to the hinder lower corner of the metapterygoid (35), but since the cartilage (if there) has been removed this cannot be stated as fact.

There are indications that the quadrate ossification is in two separate

sections, the lower centre radiating out upwards through the anterior lamina, and also posteriorly along the outer hinder face of the triangular columnar process. An inverted pyramidal portion of the latter column appears to be a secondary or separate ossification with centre of radiation from the apex of the inverted pyramid. This dorsal inverted pyramidal



TEXT-FIG. 11.—*Latimeria chalumnae* Smith. Left side of head with lateral dermal and parafrontal structures removed. Cartilage shown by parallel line shading (see Plate XXI). The plain arrow marks position and angle of cross-section shown in text-fig. 17, the crossed arrow that shown in text-fig. 18. The line represents 1 cm. For explanation see Folder-page I at end.

process is cancellate within, and of lighter structure than the basal portion of the bone. There is an appearance of a suture along the anterior margin of this latter process.

METAPTERYGOID (35). (EPIPTERYGOID ?.)

(Plates XXI, XXV, and XXVIII; text-figs. 11, 13, 17, and 18.)

The metapterygoid lies against the surface of the upper limb of the pterygoid; its lowest point is 47 mm. below the apex of the pterygoid. In shape the metapterygoid resembles a short-handled, broad-bladed

cleaver. The outer face of the bone is slightly concave, both longitudinally and transversely, the latter curvature having slightly the smaller radius. The anterior margin of the metapterygoid lies against the median columnar superior process of the pterygoid face. The lower portion of the bone fits closely against the outer surface of the hind limb of the pterygoid (33), and is so firmly fixed as to suggest inter-calcification or even partial fusion. This hinder limb of the pterygoid is so firmly fixed to both the quadrate and the metapterygoid as to constitute almost a single element.

The greatest length of the metapterygoid is 61 mm. and the greatest depth 41 mm. The ascending process (anterior) is directed forwards and upwards, viewed laterally, at an angle of about 30° from the horizontal. The apex almost articulates with the lower surface of the frontal (alisphenoid) (1′) immediately beneath the anterior margin of the intertemporal (49). The upper surface of the metapterygoid is fairly thick, at the lowest point of the concavity it is 10 mm. in thickness. On this concavity, and connected thereto by strong tissue, lies the end of the antotic process of the basisphenoid (42), the rounded outer surface of which lies very slightly external to the plane of the outer face of the metapterygoid. To the apex of the anterior limb (*processus ascendens*) of the metapterygoid is joined the hinder upper corner of the fronto-ethmoidal cartilage, and immediately above this commissure originates the endochondral portion of the lateral canal (J) for the ophthalmic branches of the nerves V and VII.

The upper surface of the metapterygoid extends approximately 20 mm. above the margin of the hinder limb of the pterygoid. The hind margin of the metapterygoid is sharply convex and very porous except for the outer surface. Cartilage has obviously been attached along the greater portion of this edge, part of which may have been joined also to the quadrate. At the lower corner the metapterygoid is no thicker than 2 mm., but it thickens dorsally, chiefly antero-dorsally. The hinder edge is 4 mm. in thickness. The blunted apex of the anterior process is uniformly 9–10 mm. in thickness.

The front surface of the metapterygoid is inclined at an angle of about 30° from the vertical sagittal plane, and about 25° from the vertical transverse plane. The inner margin of the anterior apex is separated from its antimere by 16 mm. The inner margin of the inner lowest point of the surface of the metapterygoid, upon which the antotic process (42) rests, is separated from its antimere by 35 mm. The centre of radiation of the metapterygoid is not very obvious, but appears to lie near the base of the anterior ascending process.

The prootic (93) lies behind the middle of the metapterygoid, the hinder end projecting beyond the hind margin of that bone.

Pterygoid (35).

(Plates XXI, XXII, XXV, XXVII, and XXVIII; text-figs. 6, 11, 13, 16, 17, and 18.)

The pterygoid is by far the largest ossification in the head, and is broadly trilobate, the anterior lobe being the greatest, the hinder, lowest behind the quadrate the least. The greatest longitudinal length of the pterygoid is 156 mm. and its greatest height is approximately 112 mm. The radial centre of the structure lies immediately anterior to, and slightly below, the apex of the quadrate (34). The main foundations of the pterygoid are three stout columnar processes. The lower, about 125 mm. in length, runs almost horizontally towards the anterior apex of the structure, which articulates beneath the hinder lower surface of the autopalatine (37). The median process is about 90 mm. in length and runs at an angle of approximately 45° from the horizontal, upwards and inwards, to end beneath the upper portion of the metapterygoid (35). The hinder upper margin of this middle ridge is trenchant, and almost overlaps the anterior outer face of the metapterygoid. The posterior and stoutest process of the pterygoid rises posteriorly from the radial centre at only a slight angle from the vertical in all directions, and extends upwards curving behind the metapterygoid to meet the posterior flange from the median process of the pterygoid in a broad curve. The upper and hinder face of this hinder pterygoidal process is broadly bevelled posteriorly, the bevelling on the level of the marginal articulation of the metapterygoid being about 15 mm. in width downwards and backwards. The bone connecting the median and hinder columnar processes has a deeply concave surface, to the upper portion of which the lower limb of the metapterygoid is ankylosed. The laminate structure between the median and the anterior pterygoidal processes is triangular, with an obtuse angle against the median columnar pterygoidal process. The apical angle is approximately 100°, the base of the triangle is approximately 110 mm. and the height about 58 mm. The upper anterior margin of this lamina is very gently convex, viewed laterally is almost straight, with no notch or emargination. This triangular lamina is fairly deeply concave, the lowest point of the surface near the upper margin being 19 mm. below the plane joining the upper edges of the median and the anterior pterygoidal columnar processes. The radial curvature is comparatively slight.

Along the middle of the upper surface of the laminate process of the pterygoid the antimere lies 25 mm. away. The lower hinder lobe of the pterygoid lies exterior to the upper anterior area enclosed by the marginal columnar processes.

Below the anterior limb there is an inferior triangular portion of the pterygoid approximately 24 mm. in height and 55 mm. in longitudinal length to the anterior margin of the quadrate. The pterygoid at this point passes behind the quadrate, 15 mm. above the quadrate articulation of the lower jaw, and curves upwards and backwards to meet the outer flange from the hinder pterygoidal process which runs downwards, its hinder extremity being coincident with the upper hinder edge of the columnar process of the quadrate.

Autopalatine (37).

(Plates XXI, XXII, XXV, and XXVII; text-figs. 6, 7, and 11.)

The autopalatine is a prominent structure in the anterior portion of the upper part of the palate. In lateral view it is an almost equilateral triangle, with side 38 mm. in length and base 41 mm. Externally the hinder portion is overlapped by the ectopterygoid (36), while internally the autopalatine overlaps 14 mm. of the apex of the anterior limb of the pterygoid (33). The outer face of the autopalatine is longitudinally almost plane, but the profile transversely is deeply concave. There is a lateral inferior limb of convex margin which forms part of the border of the upper jaw, whose hinder portion is overlapped by the upper flange of the ectopterygoid (36). The deepest point of the concavity is 9 mm. beneath the straight line joining the apex and the external margin of the lower autopalatine limb. The upper outer surface is inclined at an angle of approximately 125° from the lower. Posteriorly the inner edge of the autopalatine does not follow the curve of the outer edge, but forms an angle by the broadening of the bone towards the lower hinder inner angle. Thus the upper limb of the posterior face of the autopalatine is a triangle with the apical angle very acute, with width of base 8 mm. and height 27 mm., the bone at the apex being 2 mm. in thickness. From the hinder inner corner the outer lower portion of the hind limb of the autopalatine passes outwards beneath the ectopterygoid (36). Thus whereas the outer face of the autopalatine is curved transversely, the hinder face is obtusely angular in cross-section with the inner inferior apex as a longitudinal ridge along the inner base of the whole structure (text-fig. 7).

Anteriorly the lower corner of the autopalatine curves inwards and forwards to form a thick tapering inner basal flange, which is an inward extension of the ridge from the posterior margin. The hinder inner edge of this flange articulates with the outer anterior apex of the parasphenoid (52), just where the vertical process of the parasphenoid originates. This basal projecting portion of the autopalatine is overlapped by the outer

margin of the base of the ectethmoid (38). The transverse section of the anterior portion of the autopalatine is shown in text-fig. 7.

Apparently firmly adherent to the autopalatine is the third lateral dental plate (37″) (Plates XI, XXI, and XXV; text-figs. 7 and 10), in which are inserted two powerful tusks as described under Upper Jaw. The inner face of the autopalatine lies 70 mm. from its antimere.

Ectopterygoid (36).

(Plates XXI, XXII, XXV, and XXVII; text-figs. 6, 10, 11, and 16.)

The ectopterygoid is comparatively long and slender and runs external to the outer lower flange of the anterior limb of the pterygoid (33). It is connected thereto inferiorly by skin, medio-superiorly by cartilage for the greatest part of its length. It originates 47 mm. in advance of the anterior margin of the quadrate, exactly opposite to the anterior edge of the upper limb of the coronoid (41), and 20 mm. internally from that point. The total length of the ectopterygoid is 90 mm. and its greatest breadth is 10 mm. Its upper surface is in shape a triangle with very obtuse apical angle, 1·4 times farther from the posterior than from the anterior corner. The ectopterygoid is joined to the pterygoid for 57 mm. of its length, the actual cartilaginous union ending 21 mm. behind the anterior apex of the pterygoidal flange. The apex of the upper flange of the ectopterygoid just overlaps the outer edge of the pterygoid. From there the inner edge of the ectopterygoid curves gently forward as a very fine lamina overlapping and attached to the hinder part of the outer lower limb of the autopalatine (37) for 20 mm. of its length.

In transverse section the ectopterygoid is U-shaped, with a much thickened base and rapidly tapering apically pointed limbs. Along the lateral margin (apex of curve of the U) the ectopterygoid is superiorly convex in outline. From above, the marginal outline of the structure is slightly sinuous, with concavity opposite the apex of the broadest portion.

The ectopterygoid is apparently the only bone in which large teeth are implanted directly (see Upper Jaw).

Ectethmoid (38).

(Plates XVII, XXI, XXII, XXV, and XXVII; text-figs. 6, 7, and 11.)

This ossification lies just beyond the ethmoid region, anterior and joined to the palato-quadrate limb. I had earlier (Nature, 1939, vol. cxliii, p. 455) stated this bone to be a prevomer. Later investigation has revealed its true nature as an ectethmoidal ossification.

Internally the structure is but lightly ossified, rather cancellate, while the surface laminae are dense. It is composed of a fan-shaped base which is set in the antero-lateral margin of the upper jaw, with the angle of the fan lateral, adjacent to the anterior corner of the autopalatine (37). On the posterior margin of the base there rises from within, curving laterally upwards, a subvertical flange. From the outer (hinder) angle of the base there arises an inverted pyramidal column which meets and overlaps the flange from the hinder edge of the base. This column is set at an angle of about 60° to the plane of the base, and lies in the same plane as the posterior flange to which it is fused and over which it lies. The column thus forms the upper lateral margin of this posterior flange.

In the front of the column, near the base, is a notch in which rests the small base of the rostro-nasal (18). Higher up the column is a facet against which the hind margin of the lateral limb of the rostro-nasal rests.

The greatest length of the base is: below 37 mm., above 33 mm., the difference being the width of the posterior flange. The maximum width of the base is 30 mm., and it is 4 mm. in average thickness. The length of the side of the base along the base of the columnar process is 32 mm. externally and 26 mm. internally. The columnar process is about 34 mm. in oblique length. The highest point of the column is 21 mm. above the upper surface of the base. At the apex, the outer face of the columnar process is 12 mm. in width, somewhat narrower at the base.

The ectethmoid is separated by the least distance of 20 mm. from its antimere. It rests upon, and is firmly bound to, the inner anterior foot of the autopalatine (37), covers entirely the prevomer (53), and overlaps the anterior outer portion of the parasphenoid (52). The inner curved margin of the base rests against the slight ridge which forms one margin of the wide and shallow central trough in the upper surface of the parasphenoid (Plate XXVII).

The upper face of the dorsal flange of the ectethmoid, including the triangular dorsal face of the pyramidal process, is joined to the flange of the anterior chondrocranium. The outer margin of the hinder face of the pyramidal process of the ectethmoid is firmly bound by tissue to the anterior face of the autopalatine (37). The foot of the lateral rostro-nasal (18) rests in, and is firmly bound by tissue to, a notch at the base of the columnar process of 38, and the main body of the bone (18) lies so as to close in most of the space between the anterior face of the base and the columnar process of the ectethmoid. This whole structure is the main encasement for the olfactory capsules, providing bony support for floor, anterior, posterior, and lateral walls.

The centre of radiation appears to lie at or about the foot of the columnar process of the ectethmoid.

In so far as I can determine, a complete ectethmoid has not been identified in any Coelacanthid remains. I cannot see any such structure in the figures I have examined. In several cases an impression of the basal portion has been observed.

Prevomer (53).

(Plate XXVII; text-fig. 7.)

The structure which is here provisionally termed the prevomer is an insignificant, rather indefinite, small, anterior adhesion to the inner face of the inner anterior flange of the autopalatine (37). It is an ossified, roughly oval structure covered with adherent loose tissue, 15 mm. in longitudinal length and 9 mm. in width. Its inner posterior margin almost articulates with the anterior trenchant edge of the parasphenoid wing (52). The upper surface of this structure is completely covered by the base of the ectethmoid (38). Very firmly attached to this prevomer is the dermal plate (53″) described under Upper Jaw.

I have not ventured to remove the autopalatine-prevomer structure. The general appearance and inseparate mobility of the two apparent sections render it possible that this so-called prevomer may be merely an endo-anterior expansion of the lower anterior flange of the autopalatine (37). An irregular groove between the autopalatine (37) and the prevomer is obvious, and it is possible that they are two separate structures. Between the prevomer and the mid-line, *i.e.* anterior to the parasphenoid (52) and above the postrostral plate (91), there is no ossified structure other than the roofing lower surface of the ectethmoid (38), which does not meet its antimere across the palate.

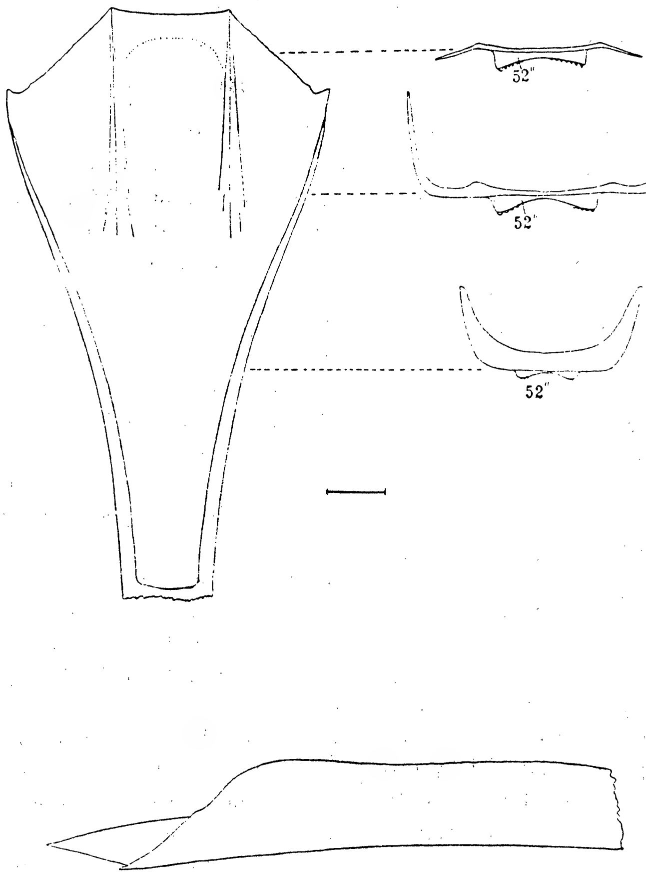
Parasphenoid (52).

(Plate XXVII; text-figs. 7, 10, 12, 15, and 16.)

The parasphenoid is an unexpectedly massive structure, but is unfortunately incomplete, the hinder portion having been removed by the taxidermist. It originates 23 mm. from the tip of the rostrum, the portion remaining being 100 mm in length.

In shape the parasphenoid resembles a grocer's scoop, tapering posteriorly to the narrower shank. The shape may be understood by reference to text-fig. 12. Anteriorly the parasphenoid is lamino-radiate in structure, the hinder thicker portion being still densely ossified but somewhat cancellate. The lateral vertical process is anteriorly very thin, but becomes increasingly thicker posteriorly. The anterior point of the parasphenoid is on each side the termination of a longitudinal ridge, which extends approximately 40 mm. along the upper surface. Between these ridges

the bone is gently concave, forming a shallow trough. The portion of the chondro-cranium which remains has for its base the trough of the hinder part of the parasphenoid, and this anterior shallower trough of the bone.



TEXT-FIG. 12.—*Latimeria chalumnae* Smith. Parasphenoid (incomplete) × 0·75.
Above : dorsal view, with position of anterior edge of dentate plate (52″) shown by the curved dotted line.
On right : transverse sections at points shown by interrupted lines.
Below : lateral view.

The lateral anterior wing of the parasphenoid is covered by the base of the ectethmoid (38), which fits closely to the surface. The inner margin of the ectethmoid extends to the apex of the small anterior superficial ridge, and covers the parasphenoid inwardly for 15 mm. of its width. It is difficult to determine the centre of radiation of the parasphenoid, but it appears to lie in the base of the trough approximately 80 mm. from the

anterior margin. I am unable to determine whether there is any cavity between the parasphenoid and its dermal plate (52″). The latter originates 5–6 mm. behind the front margin of the parasphenoid (text-fig. 12). The dermal plate is described under Upper Jaw. It appears to be very firmly attached.

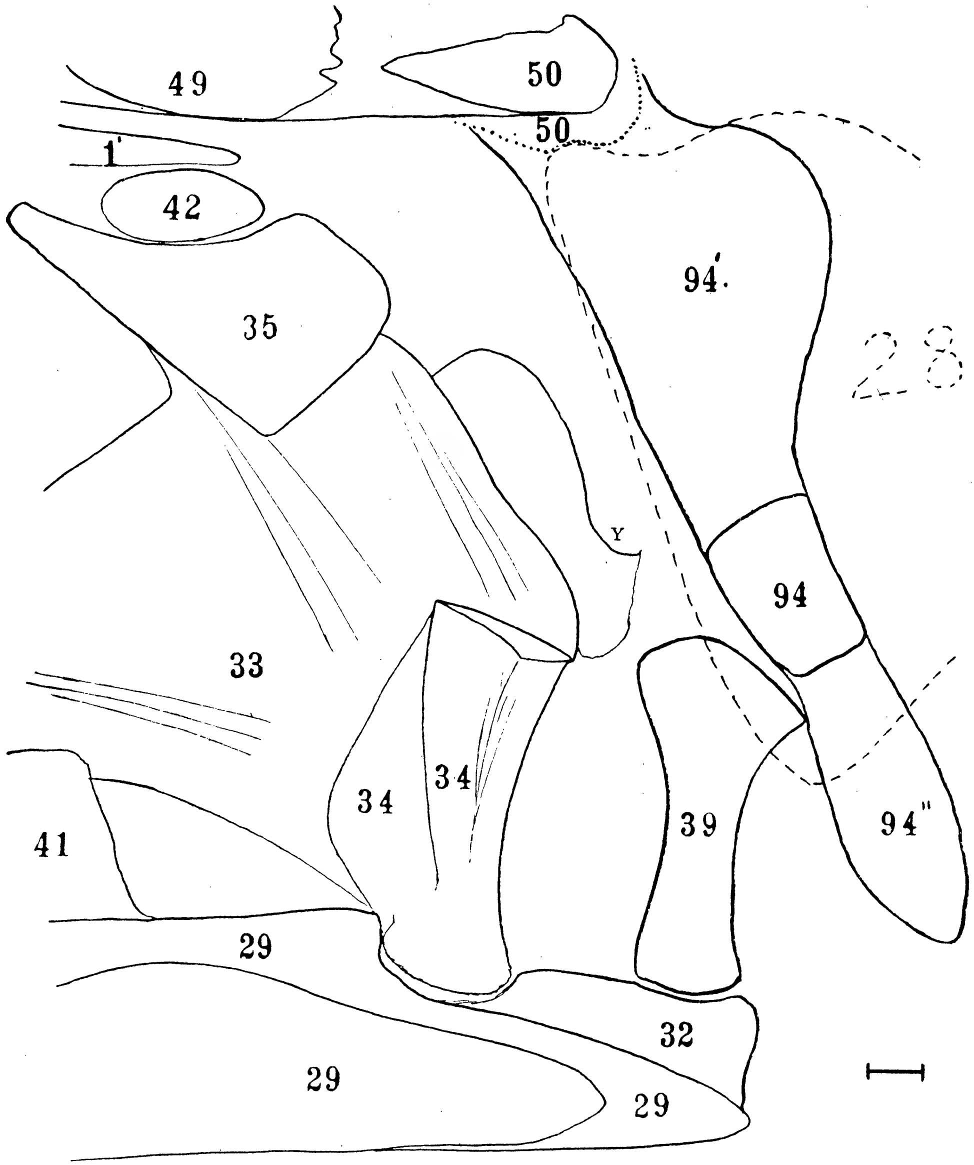
Hyomandibular (94).

(Plate XXX; text-fig. 13.)

The structure here termed the hyomandibular is a typical cartilage plus median ossification complex, extending obliquely downwards and backwards from the operculo-supratemporal articulation, along the inner face of the anterior margin of the opercular and below. It is very firmly bound to the inner face of the opercular (28) and to the supratemporal (50), and midway along its length to the upper face of the symplectic (39) (text-fig. 13). The structure is approximately 150 mm. in total length and of average width 20 mm. The lower section (94″) consists of cartilage approximately 8 mm. in thickness, and is 55 mm. in height. The median portion (94) of the structure is ossified. It is 30 mm. in height, 21 mm. in width; inferiorly 14 mm., superiorly 11 mm., in thickness. The bony walls are fairly thin, and it is either hollow or cancello-porous within. It appears to be merely a bony capsule.

Superiorly (94′) the structure for 65 mm. consists of cartilage approximately 7 mm. in thickness, and is expanded to an overall width of about 50 mm., the upper anterior edge being immediately beneath and overlapping inside the opercular-supratemporal articulation. The opercular (28) is firmly held by this structure.

The inner face of the hyomandibular from the lowest portion of the ossified capsule is covered by thin but tough skin, whose upper surface is covered by marginally articulating subrhombic scale-like dentate plates. The posterior plates are small with feeble dentition, whereas a vertical row of five along the inner anterior margin of the ossification are large, and bear three to five graduated sharp spines. The centre plate is 9 mm. in height and 5 mm. in width. The posterior margin of each plate is composed of numerous graduated close-set acute denticles, and the anterior margin bears five antrorse spines of which the centre is the largest, 5 mm. in length. This squamation extends up above and forward of the symplectic (39), and the skin there forms a lobate marginally thickened fold (Y) (Plates XXI, XXV, and XXVIII), which possibly formed or covered the hinder edge of the hyoidean gill slit (H). Externally these articulating scale-like plates gradually diminish in size and spination posteriorly and superiorly on the skin. The spines are in every respect identical in structure with the teeth of the rostral plates (*q.v.*). They are generally more



TEXT-FIG. 13.—*Latimeria chalumnae* Smith. Left side of head with outer skin and dermal cheek-bones removed, showing hyomandibular. The opercular is shown by interrupted outline. The line represents 1 cm. For explanation see Folder-page I at end.

slender and apically more heavily enamelled, and the pulp cavity is not as large, but extends almost to the apex.

The structure identified in *Wimania sinuosa* Stensiö by Stensiö (Stensiö, Triassic Fishes, Spitzbergen, 1921, p. 74) as an epihyal I am inclined to consider represents the medial capsular ossification of an hyomandibulary system, which would lie in the position described, *i.e.* postero-medially of the pterygoid.

Symplectic (39).

(Plate XXX; text-fig. 13.)

In a brief note to Nature (1939, vol. cxliii, No. 3627, p. 749) I stated that an epihyal and a ceratohyal were present in this specimen. I had not at that time ventured to explore within the skin above the inner side of the articular (32), and considered the structure now termed symplectic to have been the upper limb of the ceratohyal.

This symplectic is 65 mm. in height, with shank of elliptical cross-section 11 mm. in width at narrowest part, which occurs about midway along its length. Both ends are dilated, the lower along both axes of the ellipse, and the upper along the major axis, with some decrease along the minor (text-fig. 13). The lower condyle articulates with a facet on the dorsal surface of the hinder portion of the articular (32), the joint being firmly enveloped in cartilage.

The upper end spreads more or less fanwise, posteriorly exaggerated so as to give a projecting lobe. The outer surface of the symplectic is firmly attached to the inner surface of the thick preopercular flap, and is firmly bound thereto by a covering of extremely tough skin. The upper edge of the superior dilation is firmly attached by cartilage to the anterior face of the hyomandibular complex (94), the ossified lower corner of that structure almost touching the hinder upper edge of the bone of the symplectic. The outer face of the end of the hinder lobe of the symplectic is firmly bound to the inner face of the lower corner of the opercular (28). There is no point at any portion of the inner surface of this symplectic where a ceratohyal could have articulated. The investing skin was complete and covered the whole surface.

In pl. iv, fig. 2 (Stensiö, Triassic Fishes, Spitzbergen, 1921), there shows in *Wimania sinuosa* Stensiö a bone labelled by Stensiö "*y*," and described by him in the legend as "*y*, loose bone probably from the shoulder girdle." That bone I consider to be identical with that here described as a symplectic. It has been disturbed hardly at all from the position it should have as deduced from what I have seen in *Latimeria chalumnae*, *i.e.* it lies almost parallel with and just posterior to the quadrate, its lower

end articulating with the upper surface of the articular, and the dilated head partly behind the opercular.

In pl. xi (*ibid.*) of *Axelia robusta* Stensiö (specimen P. 195), Stensiö labels a fragment of bone "*Br*," designated in the legend as portion of a ceratobranchial. This may be part of the symplectic.

This bone may legitimately be termed symplectic despite the fact that it does not unite the hyomandibular directly with the quadrate. It is possible that the system in this fish is the typically primitive relationship between the pterygoidal and the hyomandibulary arches. The hyomandibulary system in *Polypterus* suggests that the hyomandibular itself of those fishes has been formed by fusion of the elements here termed hyomandibular (94) and symplectic (39). The system in *Amia* is not widely divergent, while those of existing Chondrostei show marked similarity in structure and function to that described in *Latimeria*. (This in so far as I am able to deduce from diagrams, not having any material for dissection.)

The Fronto-intertemporal Joint and its Structural Relationships.

In Coelacanthid remains the head often appears to have broken transversely between the frontals and the intertemporals. It has been generally accepted that some form of joint in, or division of, the skull occurred at that part. In the light of what has now been learned, this transverse cleft has probably been somewhat exaggerated in most reconstructions. It had been supposed that there was some degree of flexion between the anterior and the post-frontal parts of the head. My observations incline me to the view that the Coelacanth head possesses rigidity in greater degree than has been supposed, but that there is quite probably some degree of independence of movement between the anterior and the posterior parts. A slight degree of flexibility might assist in the firm locking of the jaws if strong jaw muscles are present, which appears to be the case in this specimen.

This characteristic fronto-intertemporal joint is clearly marked in this specimen, its course being visible as a depression in the shrunken skin posterior to the exposed parts of the frontals. The intertemporals (49) are firmly sutured along the mid-line of the head, while the frontals are rather loosely articulated with one another. The posterior edge of the main lamina of the frontal is somewhat irregularly bevelled downwards. This produces a narrow V-shaped gap between the hind margin of the frontal and the anterior margin of the intertemporal, the lower edges more or less articulating and bound together by tissue below. The roof

of the chondrocranium is firmly bound to the lower surfaces of the bones. There is no cartilage or other tissue between the frontals and the intertemporals in the trough of the joint. Superiorly, over the trough the two bones are united by the thick skin of the head, which is firmly anchored to the base of the exposed portion of the bones composing the joint. In so far some degree of flexibility may be expected in such a structure. The whole is, however, continued posteriorly by the infero-posterior process of the frontal, the alisphenoid (1′). This projects obliquely backwards beneath and almost parallel with the ventral surface of the intertemporal, to which it is firmly bound by tissue. At the same time it overlaps the antotic process (42) of the basisphenoid, to which it is as firmly bound, the latter in turn being fixed to the upper surface of the metapterygoid (35) between the ascending and the antotic processes of that bone. Internally the inner edge of the alisphenoid is almost certainly invested by the cranial cartilage. The frontal (1) is thus firmly bound to the intertemporal (49) and becomes an integral part of the pterygo-quadrate system. The whole of the forepart of the head is therefore united with the posterior limits of the pterygoidal system in such a manner as to produce a strong and fairly rigid structure.

Via the ramus of the lower jaw, the hyomandibulary system is connected with the quadrato-pterygoidal column. The opercular (28), in virtue of its relation to the hyomandibular (*q.v.*), is functionally also an integral part of that system.

The postfrontal, *i.e.* intertemporal-supratemporal, region of the skull, is to some extent a separate entity. It is almost merely a roofing, albeit massive, structure, anchored by the ventral surface anteriorly to the quadrato-pterygo-frontal, and posteriorly to the operculo-hyomandibulary systems, thereby linking those structures dorsally.

The base of the cranium, chiefly through the antotic processes of the basisphenoid, is at least in part dependent upon suspension from the pterygoidal columns. The sphenoidal structure provides additional strength and rigidity to the main skeletal system, since it restricts or prevents any lateral movement of the pterygo-quadrate columns.

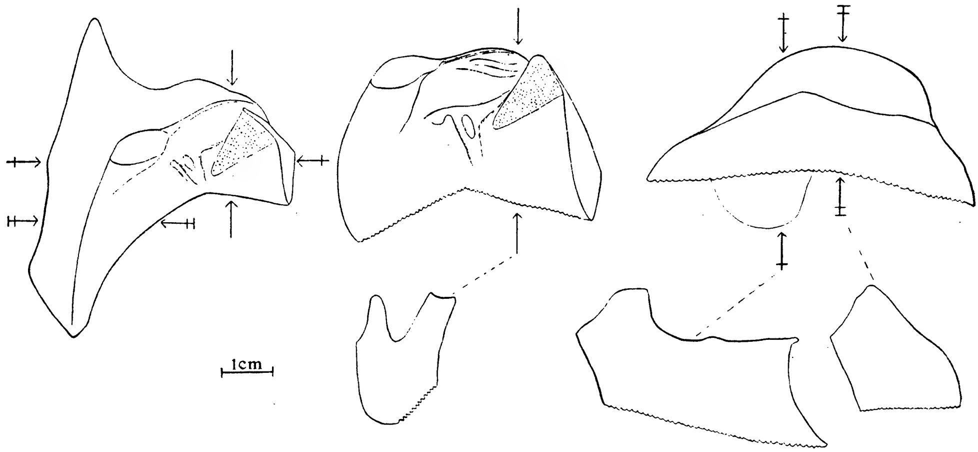
Prootic (93).

(Plates XXI and XXVIII; text-figs. 11, 14, 17, and 18.)

Only the dorso-lateral portion of this structure remains, the rest having been sliced away by the taxidermist. The portion remaining has an inner face which lies in the lateral wall of the brain cavity. This face is approximately 63 mm. in length and 27 mm. in height, and it lies almost parallel with the sagittal axis. Outside this process is a large semi-compressed

columnar projection which lies over somewhat towards the inside, thus presenting a lateral surface which faces upwards and outwards. In external appearance this structure is somewhat spindle-like, the anterior limb being the lateral basal structure of the inner face, and the posterior limb the columnar projection previously described.

Along the upper edge of the inner face the prootic is attached by firm cartilaginous tissue to the inner inferior margin of the intertemporal (49),



TEXT-FIG. 14.—*Latimeria chalumnae* Smith. Remaining portion of prootic (93).

Top left : View from above.
Top centre : Lateral view, much as position shown in Plate XXVIII.
Top right : View of inner face which forms part of the lateral wall of the brain cavity. Articulation facet for supratemporal infero-antrorse process (50′) dotted.
Below : Cross-sections, taken as shown by plain, one-barred, and two-barred arrows. Jagged edges show where portions of the structure had been removed.

the whole apparently having formed part of the lateral wall of the neurocranial cavity. The upper inner edge of the postero-exterior columnar limb appeared to have been attached by cartilage to the inner lower ridge of the supratemporals (50). Unfortunately this part had been so mutilated that I can give little information about it. On the upper hinder margin of the lateral face of the posterior columnar process is the triangular facet for reception of the laminate infero-antrorse process (50′) of the supratemporal. Slightly anterior and below the apex of this facet, the face of the bone is moulded to receive the covering ossicle (92), which, by envelopment of the base within stout tissue, is firmly bound to this outer limb of the prootic, serving to bind the supratemporal process also.

It is exceedingly difficult to describe this structure adequately, but various views and sections are shown in text-fig. 14.

In the dorsal portion of the posterior columnar limb is a deep channel

filled with the cartilage which spreads over the outer hinder face of the column, and which is attached superiorly to the supratemporal (50). A canal 2–3 mm. in diameter runs through this cartilage, which probably carried branches of nerves V and VII, but I am not prepared to be definite on this point. At any rate, these nerves appear to have run forward and downward along the outer face of the prootic after emerging from the groove. There is a deep excavation in the lateral face of the anterior limb, but I cannot be certain whether it is artificial or not, though it appears not to be natural.

The whole prootic is extremely light and cancellate in structure. The inner face bears an angular median, fairly sharp longitudinal ridge. Most of the anterior limb of the structure lies within and behind the metapterygoid (35). The posterior limb, with the covering ossicle, becomes visible externally when the postorbital (23) and the squamosal (24) are removed.

Prootic Ossicle (92).

(Plates XXI and XXVIII; text-fig. 11.)

Over the end of the supratemporal process, and overlapping it, is a small capsular ossification of peculiar structure (92), which is firmly bound to the lateral face of the prootic (93) by strong tissue. This structure binds the supratemporal limb (50′) very firmly to the prootic (93) also, since the pointed apex of the former lies in a slight moulded fossa in the face of the prootic. This external structure I name provisionally "prootic ossicle." In so far as I can determine it serves chiefly as a binding element, possibly also as a form of protection for the branches of the V and VII nerves, which appear to run along the lateral face of the prootic (*q.v.*).

This ossicle (Plate XXVIII) is merely a capsule of very light structure. It consists of a basal plate, roughly tri-equiangular, of side 16 mm., which rests against the lateral vertical face of the prootic. From the lateral (outer) face of the base of the ossicle arises a hollow structure which turns immediately downwards and dilates inferiorly, chiefly posteriorly, into a lobe 17 mm. in length and 7 mm. in height. This lobe hangs over and not far beyond the margin of the lower portion of the base, with its outer face about 7 mm. outward from the base. This lower lobe thus projects downwards as a flange over the lower outer face of the prootic.

In contrast with the smooth surfaces of the supratemporal inferior limb (50′) and of the outer face of the prootic (93), the surface of this ossicle (92) is reticulately rugose and striate. The surface ridges may be covered with ganoin. The prootic articulation with and without the ossicle (92) is figured in Plate XXVIII. The form of the structure on the prootic suggests a small external "ear." Actually the whole supra-

temporal-prootic articulation complex is not visible externally, being covered by the hind margin of the preopercular system. It is connected with the outside by the external opening of the antotic cavity (V) on the outer face of whose inner wall it lies. This antotic cavity opens behind the "preopercular system" (hind limbs of postorbital (23), squamosal (24), and preopercular (25)).

So light is this ossicle that it would probably not often remain with the heavier structures during decomposition, and would probably not often be seen with fossil remains. I am inclined to consider that it shows in a figure (Stensiö, Triassic Fishes, Spitzbergen, 1921, pl. xi) of *Axelia robusta* Stensiö labelled "Pro-o.," described in the legend as "Only a postero-lateral part of the prootico-opisthotic." It appears from the figure that the ossicle has suffered an anticlockwise twist through about 90°, the hinder part of the outer lobe thus pointing upwards. In pl. xiii (*ibid.*) the impression of the base of this ossicle is probably indicated by "Pro-o."

Chondrocranium.

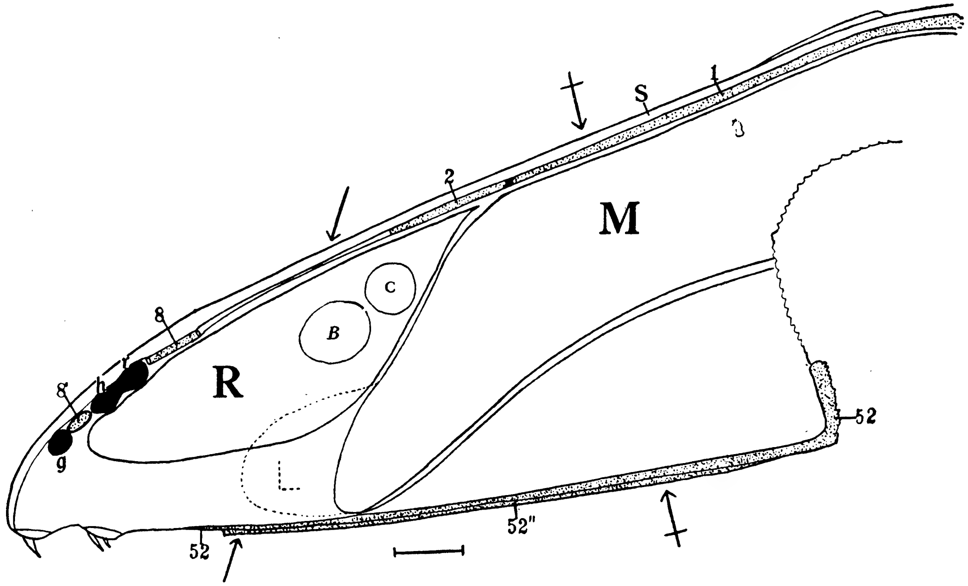
(Plates XXI, XXII, XXV, and XXVII; text-figs. 6, 7, 11, 15, 16, 17, and 18.)

This structure was somewhat hacked about during mounting. Anterior to the intertemporals (49), the central portion at least appears to be complete. The posterior portion has only the upper and upper lateral portions. It is almost impossible to trace the origins and exits of the cranial nerves from what remains. Only the course of the ophthalmic branches of the V and VII nerves has been found. Even anterior to the intertemporals, the median portion, *i.e.* the posterior flange from the interorbital septum, has been cut away. The remaining portion of the anterior part of the chondrocranium is in transverse section almost triangular, resting on a blunted apex in the trough of the parasphenoid (52), which widens anteriorly. This is shown in text-figs. 7, 15, and 16.

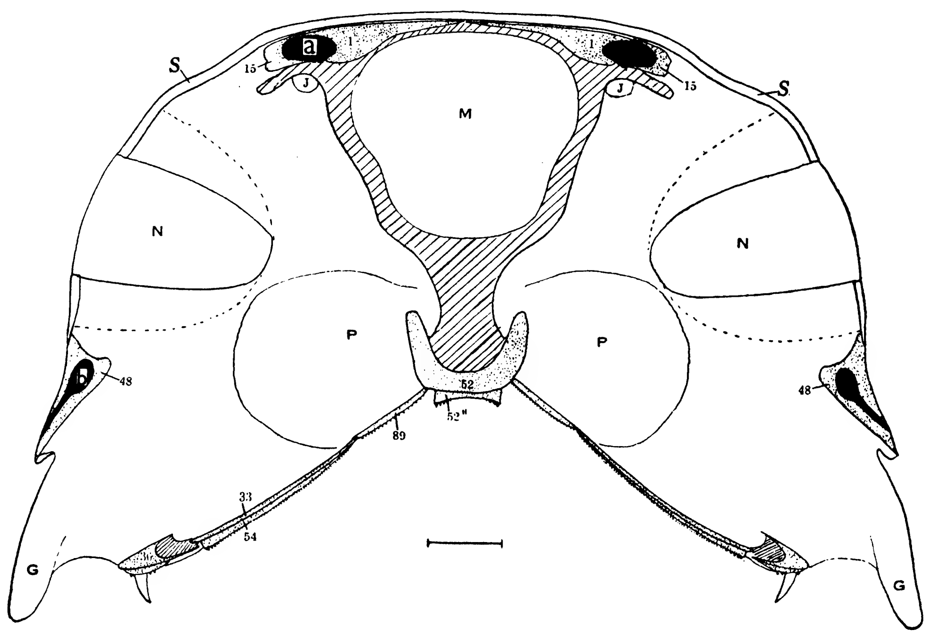
The upper surface of the anterior part of the chondrocranium is gently convex, the fronto-rostral series of bones resting upon and fixed to it. This surface spreads laterally to form a narrow flange curving over the orbital and nasal structures. Anteriorly the flange is joined to the top of the columnar process of the ectethmoid (38), posteriorly to the metapterygoid (35).

Adjacent to the basal portion of the chondrocranium in the parasphenoidal groove were the remains of a relatively large muscle sheath (P), probably for the anterior muscles of the eye.

From the foramen (J) in the alisphenoid (1′) the dorsal branches of the V and VII nerves pass into a tube in the lateral flange of the chondro-



TEXT-FIG. 15.—*Latimeria chalumnae* Smith. Sagittal section of anterior neurocranium. Sensory canals heavy black. Bone sections dotted. The anterior plain arrows show the position of the transverse section figured in text-fig. 7, the barred arrows that figured in text-fig. 16. The line represents 1 cm. For explanation see Folder-page I at end.



TEXT-FIG. 16.—*Latimeria chalumnae* Smith. Transverse section of head 100 mm. from snout tip (see text-fig. 15). Cartilage shown by parallel line shading. Sensory canals black. Bone sections dotted. The line represents 1 cm. For explanation see Folder-page I at end.

cranium. This continues forwards for about 20 mm. and then emerges to run beneath the flange. Finally the nerve channel again pierces the flange to open into the upper lateral narial tube (C), thence to the lower lateral narial tube (B), and finally to or over the olfactory capsule (E) also. (See Olfactory Organs.)

In the anterior part of the chondrocranium lies the large ethmoidal cavity (R) (*q.v.* under Olfactory Organs). Beneath this lie the olfactory lobes (L) of the fore-brain (text-figs. 7 and 15). Antero-laterally to these are the olfactory capsules (E) bounded postero-laterally by the ectethmoid (38).

Brain Cavity (M).

The brain in this specimen shows a typical primitive anterior prolongation. The roof of the brain cavity sweeps as unbroken cartilage from the hind margin of the intertemporals (49) forwards to the rostrum. The fore-brain is of moderate diameter, and the tubular cavity dips downwards in the anterior chondrocranium to run beneath the rostral sinus (R). The brain divides below the hind margin of that sinus. There is a small double depression on the lateral walls of the anterior brain cavity, but it is not a foramen (text-fig. 15). In the apex of the cavity for the olfactory lobe there is a foramen for the entry of nerve I to the olfactory capsule (E).

The interorbital septum is fairly thick (and entirely cartilaginous). Little can be said about the posterior portion of the chondrocranium, since most of it had been removed, and I did not dissect that region of the roof of the neurocranium. As has been mentioned, the chondrocranial ossifications, excepting a portion of the prootic (*q.v.*) and the apex of the antotic process of the basisphenoid, have been removed.

In text-figs. 17 and 18 the probable size of the brain cavity posterior to the frontals has been indicated.

Basisphenoid (96).

All that remains of the basisphenoid is the lateral extremity of the antotic process (42). Judging from this, the basisphenoid itself was but lightly ossified and highly poro-cancellate in structure.

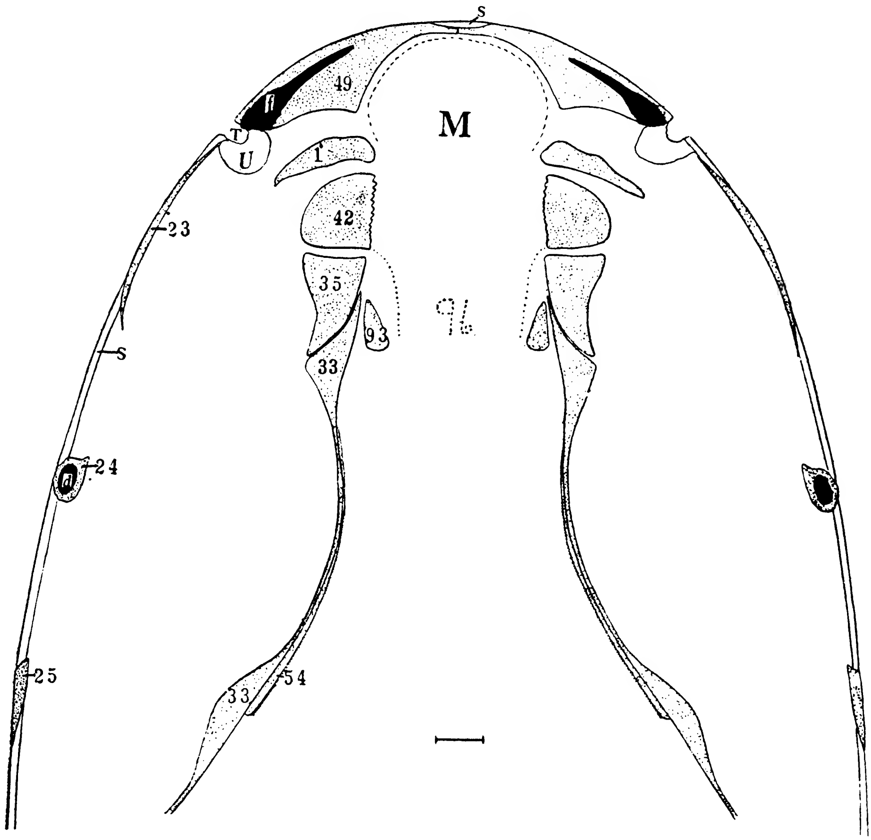
The remains of the antotic process (42) had been sliced into three parts during the mounting. The outer convex face was in position on the metapterygoid (35) with an inner slice hanging by a thread, while the third part was found in the straw with which the cranium was stuffed. The three parts fit to form a nodule which represents the lateral horizontal limb, the antotic process, of the basisphenoid. The limb is 8 mm. in depth, the nodular apex about 23 mm. in length, and faced with stout

cartilaginous tissue. It was firmly attached to the dorsal surface of the metapterygoid (35), and to the ventral face of the alisphenoid (1).

Respiratory Organs.

(Plates X, XI, XII, XIV, and XV.)

Spiracle (*F*).—The spiracles are small and situated at the anterior end of a shallow lateral spiracular groove (T). Since all the tissues beneath

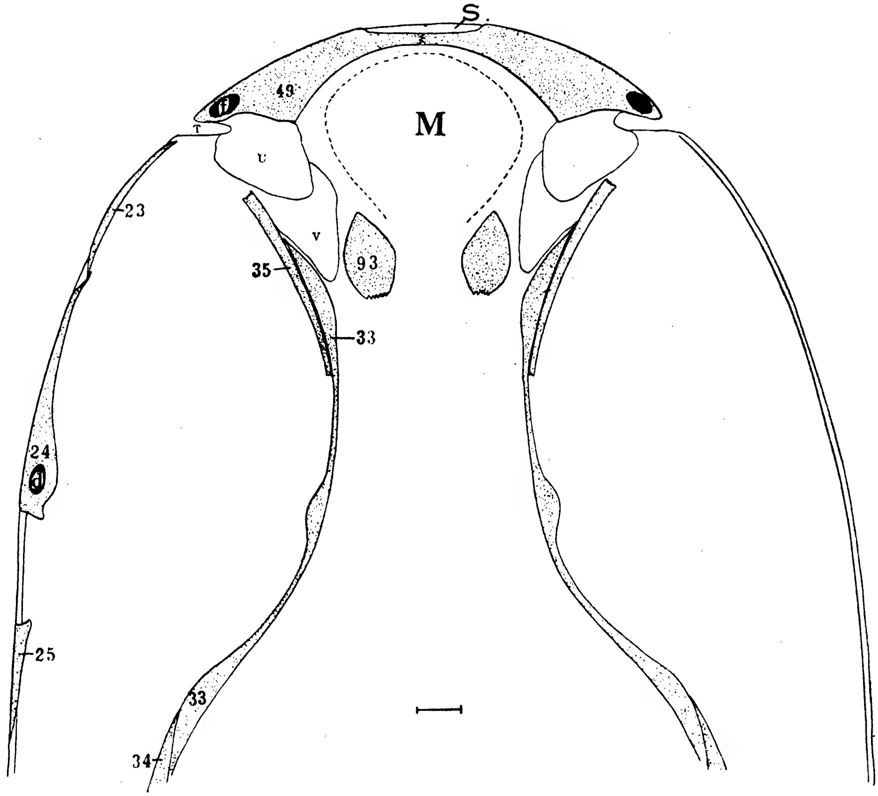


Text-fig. 17.—*Latimeria chalumnae* Smith. Transverse cross-section of head about 165 mm. from snout, indicated by plain arrow in text-fig. 11. The dotted lines indicate the possible basisphenoid in section. The interrupted lines outline the probable brain cavity. The line represents 1 cm. For explanation see Folder-page I at end.

the skin had been torn away, it is not possible to give any information about the course and nature of the spiracular tube. There is a posterior, here named spiracular pouch (U), which is described below. Its connection with the spiracle is not certain. The spiracles are probably functionless.

Gills.—Every part of the gills had been removed from this fish, and discarded, save only the copula (45, *q.v.*).

Chiefly from what I find on that organ, it seems almost certain that there were only four gill-arches. *Wimania* Stensiö and *Axelia* Stensiö



TEXT-FIG. 18.—*Latimeria chalumnae* Smith. Transverse slightly oblique section of head 185 mm. from tip of snout, indicated by crossed arrow in text-fig. 11. The brain cavity is approximate only. Bone sections dotted. The line represents 1 cm. For explanation see Folder-page I at end.

are stated to have had five. It is possible that some other structure, *e.g.* symplectic, may have been mistaken for part of a gill-arch, and that the number is constantly four.

The arches were apparently in part cartilaginous, united to the lower surface of the copula and also to some median basibranchial, whose head articulated with a facet in the hind face of the capsular basihyal ossification (100). The gill-arches are stated to have been spinate. I presume that they bore structures resembling the dentate plates occurring on the inner face of the hyomandibular (94, *q.v.*).

The gill-filaments are stated to have been "Like the ordinary gills of a fish, and reddish in colour." I cannot give any further information.

The articular-symplectic-hyomandibular system in this fish is so arranged as to make it likely that the opening of the mouth would relax the gill-cover. That is, the opercular (28), an integral part of the hyomandibular, would tend to open outwards as the post-quadrate portion of the lower jaw moved upwards. I cannot find any evidence of other muscular or tendinal control of the opercular membrane. It appears as if the opercular itself must play an important part in the control of the degree of opening of the gill-cover.

Spiracular Pouch (U).

(Text-figs. 11, 17, and 18.)

Lateral to the apex of the antotic cavity (V) lies a pouch enclosed by membrane bordering the hinder margin of the processus oticus of the metapterygoid (35). This pouch lies completely ventral to the intertemporal (49), its roof being adherent to the face of the inner inferior ridge of that bone. The hinder portion of the outer face of the pouch is covered by the postspiracular (51). The structure was damaged, but appears to have had no external opening excepting possibly anteriorly into the spiracular canal.

The pouch is 37 mm. in length, about 18 mm. maximum depth, and approximately 14 mm. transverse width. The membranous lining of the cavity is rather delicate, and though it shows no trace of being vascular, its condition does not permit of any definite opinion on that matter.

The structure probably represents a saccular diverticulum of the spiracular tube, but it would be venturesome to express any definite opinion about it, since no connection between the two could be determined with certainty. A dorsal "pouch-gill" as an adjunct to the ordinary structure of a spiracle may conceivably have been developed in some early forms, possibly of greater function than the diverticula found in some living forms. This species has so obviously retained primitive characters but little modified, if at all, that many structures found upon it will repay most detailed investigation when a complete specimen is found.

Antotic Cavity (V).

(Text-figs. 11 and 18.)

From the inner anterior surface of the opercular membrane there extends upwards and inwards a thick heavy membrane which, in thinner

form, covers the outer face of the prootic (93), and which is connected by its lower edge to the hinder face of the metapterygoid (35). It sweeps upwards to slightly in advance of the processus oticus of the metapterygoid, ending just above the antotic process of the basisphenoid (42) as a blind conical sac. The upper wall is attached to the inner ridge of the lower surface of the intertemporal (49) (text-fig. 18). It is thus extracranial, but within the pterygoidal column.

The outer apical membrane is the inner wall of the spiracular pouch (U). The hinder lower portion of the membrane, where it originates against the anterior opercular margin, is adnate to the thick cartilaginous upper section of the hyomandibular (94′) which connects the opercular (28) with the hinder outer angle of the supratemporal (50).

The lower portion of the membrane forms a rounded, vertically elongate lobe (Y) (Plates XXI, XXV, XXVIII, and XXX), much thickened and strongly dentate. Quite possibly this formed the posterior border of the presumed hyoidean gill-slit (H). The outer anterior and hinder face of the lobe bears small marginally articulating dermal plates, which are obviously modified scales, either quadrangular or rhombic. The upper outer plates bear one or two minute spines. Those on the lower anterior and inner face of the lobe bear large, slightly curved spines, mostly with an encirclement of smaller basal spines.

Postspiracular Groove (T).

(Plates X, XI, XII, XIV, XV, XVII, XXI, and XXVIII; text-figs. 11, 17, and 18.)

From behind the spiracle below the anterior third of the intertemporal (49) runs a narrow groove or trench, the trough of which is composed of fairly thick tissue, the lower portion being the roof of the spiracular pouch (U). The upper margin is formed by the lower lateral edge of the intertemporal (49) and the supratemporal (50), the lower margin by the upper edge of the postorbital (23). The hinder end of the skin of the groove overlaps the antero-inferior flange of the postspiracular (51).

Squamation.

(Plates XXX, XXXIII, XXXIV, XXXV, XXXVI, XXXVII, XXXVIII, XXXIX, XL, XLI, XLII, and XLIII; text-figs. 2, 19, and 20.)

The body is completely scaly. Only the first dorsal and the apical portions of all fin rays are naked. On the lobed fins the scales completely cover the penduncles and widen apically to form a lobe.

There are no normal scales on the head (but see Subopercular, Inter-

opercular, and Postspiracular). The anterior margin of the hinder edge of the presumed hyoidean gill-slit (H) bears articulating scale-like structures (*q.v.*). On the nape the scaling extends forwards and ends immediately behind the commissural of the supratemporal canal (*t*), and thus has an undulate margin. The two most anterior extremities of the scales are on each side 93 mm. behind the anterior margin of the intertemporals (49). On the mid-line the scales end immediately behind the inter-extrascapular (55) (text-fig. 2).

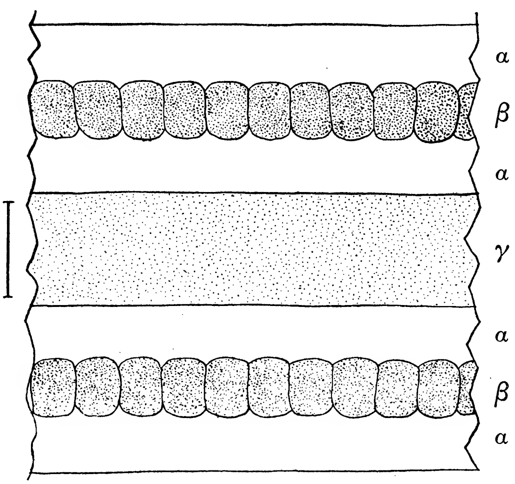
The scales are cycloid, and the whole surface is very finely corrugated with transversely striated ridges. The exposed portion of the scales is mostly covered with elongated tubercles, either rounded or posteriorly apically pointed, like spines. The scales are comparatively thick, but noticeably softer than those of ordinary teleostean fishes. They are comparatively lightly ossified. Alizarin staining and clearing of the scales is almost impossible without deformation, since they swell and partially dissolve in alkali. The tubercles also are loosened from the surface by treatment with alkali. Upon ignition of the spirit-dried unornamented portion of a mid-body scale, the residue was only 11·2 per cent. The scale of a juvenile Sparid fish, *Austrosparus auriventris* (Peters), by similar treatment, gave a residue of 32·4 per cent., and scales from a 55-lb. Sparid fish, *Cymatoceps nasutus* (Castlenau), left a residue of 51·4 per cent. In all cases the residue appeared to be chemically identical.

The circuli are comparatively fine, and exhibit some degree of annulation. From this it has appeared that the age of the specimen is possibly somewhere between twenty and twenty-five years. The annulation is of interest in indicating that the species is unlikely to be of bathybial habit.

Each tubercle is set in a more or less oval, very fine laminate basal plate, which fits exactly over the corrugations of the scale surface, the plate itself thus being corrugated. The tubercles are mostly hard and smooth above, but in some cases there appear to be indications of obsolescent blunted granulations along the base. (Tubercles of the extracleithrum, *q.v.*, have a rugose surface.) The basal plate exhibits a moderate degree of birefringence. The tubercles are hollow, the (pulp) cavity extending most of their length, and there is no obvious connection between this cavity and the base of the scale. The body of the tubercle is composed of tissue showing only the faintest trace of radial structure. This tissue shows weak birefringence with undulose extinction suggestive of strain rather than crystalline structure. In one tubercle there shows a patch which remains permanently extinguished on rotation. The outer layer of ganoin is comparatively thin, about 0·08 mm. in thickness.

The unornamented part of the surface of a scale when cleaned with

chloroform rubs into a mass of thread-like tissue. In transverse section the body of a scale is longitudinally striate, composed of layers of three distinct types (α, β, and γ) arranged in regular series. The layer α is about 6 μ in thickness and exhibits a mild degree of birefringence with fairly sharp extinction. The interference colour is light yellow. This layer appears to be uniform in structure. The layer β is about as thick as α, but is cellular and almost isotropic. The individual cells are about 4·5 μ × 6 μ. The layer γ is about 12 μ in thickness, very weakly birefringent, of blue interference colour, and apparently uniform in structure. The three layers appear to be uniformly arranged as follows: $\alpha \beta \alpha \gamma \alpha \beta \alpha \gamma$ . . . throughout the thickness of the scale. The upper series of layers are graduated slightly thicker than those below. The weak birefringence exhibited is probably due to strain rather than to crystalline structure.



TEXT-FIG. 19.—*Latimeria chalumnae* Smith. To show the arrangement of the layers and their appearance between crossed Nicols in a transverse section of the body of a scale. From a scale 0·6 mm. in thickness. The line represents 10 μ.

The scales possibly represent an advanced stage of modification of the primitive cosmoid type, in which the cancellate bone-layer has disappeared, with consequent reduction in the thickness of the scale. That the ancestral form bore true cosmoid scales is very probable (see Tooth-plates above).

Scale Counts, etc.

Lateral line 76, + 23 on the supplementary caudal, *i.e.* total 99.

23 predorsal scales from origin of scaling on nape to origin of first dorsal, 39 to origin of second dorsal, and 59 to origin of principal dorsal caudal rays. 6 scales along base of spinous dorsal, 8 from end of base of first dorsal rays to end of dorsal membrane, 6 from end of membrane to origin of second dorsal. 22 scales round the base of the peduncle of the second dorsal, 22–23 scales from the back along the anterior face of the second dorsal peduncle, 10 across the widest part of the lobe. 18 round

the base of the right pectoral peduncle, 27 from the body along the lateral face of the peduncle, and 12 across the widest part of the lobe. 22 scales round the base of the anal peduncle, 23 from the body along the anterior face of the peduncle, and 8–9 across the lobe. 18 round the base of the peduncle of the left ventral (which is damaged), 17 from the body along the peduncle, and 11 across the widest part of the lobe.

40 scales round the narrowest part of the caudal peduncle, 24 across the body from the origin of the principal dorsal caudal rays to the origin of the principal ventral caudal rays. 7 across the anterior part of the supplementary caudal. There are 5 series of basal scales on the posterior principal dorsal caudal rays.

50 scales round the body just in advance of the first dorsal, and 44 just in advance of the second dorsal. 6 series between the lateral line and the lateral margin of the base of the first dorsal, 7 to the lateral margin of the base of the second dorsal, and 13 from the lateral line to the origin of the principal dorsal caudal. 10 scales from the lateral line to the upper edge of the pelvic base, 9 to the lateral edge of the anal base, and 12 to the origin of the principal ventral caudal. From the pectoral axil to the front margin of the pelvic base there are 15 scales.

The scales are disposed in regular rows which run slightly obliquely downwards and backwards. They are largest in a roughly triangular area whose slightly convex margins run from pelvic to shoulder, and from pelvic to the base of the second dorsal fin. Naturally there is no sharp line of demarcation, but those within that area are almost uniformly large, the largest being broadly oval or even sub-quadrangular, about 50 mm. in length and 40 mm. in width, while the exposed portion of the scale is about one-fourth of the total area, and more or less rhombic (see scale 68, Plate XL).

On the body, the ornamentation on the dorsal scales is heavier and coarser than on those on the ventral surface, there being almost regular gradation in this respect. Practically the whole of the exposed surface of each dorsal scale is covered with tubercles. Ventrally the exposed surface ornamentation diminishes progressively, that of scales of the ventral surface in most cases covering not more than half of the exposed area, and the tubercles are small.

On all parts of the caudal peduncle the ornamentation on the scales is more or less uniform. On the forepart of the body the tubercles are as a rule longitudinally elongate, but vary in shape and direction of elongation, though all have an entirely smooth, gently rounded upper surface. Towards the hinder part of the body the tubercles show an increasing degree of prolongation of the hind margin, until from below the second dorsal fin they are in the form of depressed retrorse spinelets, that part of the

squamation having a coarse appearance and being rough to the touch.

The largest tubercles are found on scales in a roughly semicircular area on the dorsal surface of the body, of which the profile of the back between the two dorsals is the diameter. Nowhere are the nature and arrangement of the tubercles absolutely uniform, even in a comparatively restricted area. In one case, on the right side below the second dorsal, is an area in which the exposed surface of most scales bears 20–25 slightly irregularly caudally radiating rows of moderate tubercles, 3–10 tubercles in each row. In the centre of that area are three adjacent scales whose exposed surface is abruptly different from that of the surrounding scales, in bearing only 20–28 very large tubercles, somewhat irregularly shaped, set at all angles. Also in that same area are other scales on whose exposed surface is anteriorly a group of a few large, irregularly shaped tubercles, while the hinder portion of the ornamentation conforms with that characteristic of the area described.

There is a high degree of variation in size and shape of scales on this fish (as indeed in all fishes). The variations observed in this specimen show clearly how unreliable as even specific characters individual scales or even isolated groups of scales may be. Illustrations of scales from many different parts of the body are given in Plates XXXIII–XLII. The wide variation in size, shape, and ornamentation is clearly shown especially in Plate XLII.

There is generally abrupt differentiation between the scales on the body and those on the lobed fins. In the axil of the pectoral the scales become abruptly smaller than those on the body, and there is one with a distinctly lobate hind margin reminiscent of a rudimentary axillary scaly process (80, Plate XLII). On the limb of the fin the scales become increasingly smaller, and elongated (74 and 81, Plates XXXV and XLII), and at the base of the rays the scales are almost five times as long as wide. On the outer (lateral) face of the lobe and peduncle of the pectoral fin the ornamentation of the scales is comparatively feeble and sparse. On the opposite (inner) surface the scales are comparatively densely ornamented with small close-set spiniform tubercles (the outer lateral surface of the rays bears spines, the inner surface being smooth, the opposite of what is observed on the scales). On the body beneath the pectoral fin, the surface ornamentation of the scales becomes extremely diminished, some scales bearing only a few tubercles about the centre of the exposed area.

In the case of the pelvics the same abrupt change in the squamation is observed. The proximal scales are small, almost quadrangular (82, Plate XLII), but become distally more elongated, those at the base of the rays being elongate-oval (83, Plate XLII).

At the base of the second dorsal there is also a very abrupt change

in shape and size of the scales. On each side of the base are several upright scales whose upper surface is truncate with posterior lobation, and with only small exposed portion, almost marginal, bearing subciliate tubercles (86, Plate XLII).

Lateral Line.

The lateral line originates at the upper hinder edge of the exposed portion of the supratemporal (50), the anterior scales with strongly ossified heavy tubes. The lateral line curves gently upwards over the pectoral to within about 60 mm. of the dorsal profile at about the tenth scale. Thereafter it runs slightly downwards in almost a straight line to the fifty-first scale (65) slightly in advance of the anterior dorsal principal caudal rays. Thence the lateral line curves slightly downwards, running immediately beneath the obtuse keel-like longitudinal ridge on the middle of the peduncle. Near the hind end of the peduncle the line curves slightly upwards and continues uninterrupted to the extreme hind margin of the scaling on the supplementary caudal. The tubes of the lateral line scales bifurcate, the bifurcations generally running along the upper and lower margins of the ornamented face. The tubes open outwards by numerous small foramina, generally uniserial, in the upper face of each bifurcation. These small foramina may be seen in figures of the anterior lateral line scales.

Lateral Line Scales.

(Plates XXX, XXXIV, XXXVII, XXXVIII, XLI, and XLII; text-fig. 20.)

On the left side the first lateral line scale (60, Plate XXX) is a small but massive structure. The exposed portion is 28 mm. in height and 14 mm. maximum width. The overall length is 20 mm. The exposed portion of the scale is about two-thirds of the total surface. The outer (posterior) margin is convex, slightly undulate. The surface is sparsely covered with small rounded to elongate-oval tubercles arranged very regularly as twenty posteriorly radiating rows. The exposed surface is bounded supero-posteriorly and infero-posteriorly by the main branches from the sensory canal. Between these lie near the surface four or five smaller canals, reticulately interconnected. The portion of the scale beneath the skin is almost 7 mm. in thickness medially. Superiorly there is a normal but much abbreviated dermal flange. The hind mid-portion of the scale consists of a bony tubule, of 4 mm. internal diameter at the hinder end, which branches dorso-posteriorly. The lower main branch has numerous perforations proximally. The main tube is contained posteriorly as a solid structure 15 mm. in length, the posterior opening being directed somewhat down-

wards. The hind portion of this canal thus has the appearance of a cup-shaped projection on the lower surface of the scale. This fits closely over an outer foramen in the anterior portion of the second lateral line scale, which is the anterior end of the canal in that scale. On the ventral surface of the sensory tubule is a ventrally directed tubular process with infero-lateral aperture, obviously for innervation within the scale.

The second lateral line scale (79, Plate XLII) is merely a larger edition of the first, but of lighter structure. The outer surface bears a heavier ornamentation of larger tubules arranged in about thirty posteriorly radiating rows. The canal is 10 mm. in length, the postero-inferior portion projecting cup-like downwards. (On the right side, at the origin of the lateral line, is a large hastate scale obviously representing a fusion of two units of the type of the first and the second lateral line scales of the left side.)

Posteriorly the lateral line scales gradually change in shape. The ninth scale (62) is roughly circular with triangular exposed portion about one-third of the total surface (Plate XLI). The tube bifurcates posteriorly and the inferior cup-like projection is much reduced. The exposed surface is covered with tubercles, those anteriorly being fairly large in an irregular group. The distal tubercles are slightly smaller, and are arranged in about twenty-five caudally radiating irregular rows. On the ventral surface on the tubule and branches are numerous extremely minute foramina which may be points of innervation.

The scales of the lateral line increase in size posteriorly and attain maximum size at about the sixteenth, remaining approximately constant until about the fortieth. Thereafter they decrease rapidly in size. The eighteenth lateral line scale (63, Plate XXXVIII) is ovoid, the exposed portion being subrhombic. The scale is 41 mm. in total length and 35 mm. in maximum width. The exposed portion is 30 mm. in height and 15 mm. in width, and is about one-fourth of the total surface. The tubule is only 6 mm. in length, and more normally perforation-like. It bifurcates into two main branches bordering the exposed area, the inferior of which has several superior apertures. There appear to be also several intermediate shorter posterior branches. The exposed surface is densely covered with twenty-eight distal more or less regular posteriorly radiating series of tubules, the tubules becoming marginally smaller.

The thirty-fourth lateral line scale (64, Plate XXXVIII), which occurs below the centre of the second dorsal peduncle (text-fig. 20), is more or less rectangular, 43 mm. in length and 33 mm. maximum breadth. The exposed portion is triangular with rounded base, 16 mm. in height and base 27 mm., and comprises one-sixth of the total area. The tubule commences 25 mm. from the posterior end and bifurcates, the two main

branches bordering the exposed area. Each has a superior aperture just beyond the bifurcation. The superior branch opens on to the dorsal surface of the scale. The tubules on the exposed portion are rounded, largest in the central portion of the triangle, smaller posteriorly, where there are twenty radiating series, with smallest at the anterior apex. Tubules are absent from an area in the upper posterior angle.

The fifty-first lateral line scale (65, Plate XXXIV), which occurs five rows before the origin of the principal dorsal caudal rays (text-fig. 20), is roughly a parallelogram, 35 mm. long and 22 mm. wide. The exposed portion is a triangle of base 15 mm. and height 15 mm., about one-sixth of the total surface. The main tubule bifurcates. The tubercles are rounded, large at the anterior apex and decreasing in size posteriorly, there being ten series marginally. The small area behind the terminal aperture of the superior branch of the tubule is naked.

The sixty-fourth lateral line scale (66, Plate XXXIV) occurs slightly nearer the origin of the supplementary caudal than the origin of the principal dorsal caudal rays (text-fig. 20). It is elliptical in shape, major axis 28 mm., minor 15 mm. The exposed surface is roughly about one-twelfth of the total area. It is triangular in shape and contains only twelve subequal sharp denticles. On the main tubule and on the two branches are several minute dorsal apertures.

The eighty-eighth lateral line scale (67, Plate XXXVII) is the twelfth lateral line scale on the supplementary caudal. It is pear-shaped, 11 mm. in length and 8 mm. maximum width. The width across the dorsal opening of the main tubule is 5 mm. The exposed portion is rhombic in shape. The main tubule is 6 mm. long, and very wide compared with the side branches. The denticles are very sharp, sub-equal, and comparatively long, there being eight on the exposed portion of the scale, which is almost half of the total area.

The remaining scales (61, 68–76, 80–88), of which figures are given in Plates XXXIII, XXXV, XXXVI, XXXVII, XXXIX, XL, and XLII, are representative of the areas from which they are taken (see text-fig. 20 in Folder-page II).

Flesh and Musculature.

The taxidermist stated that the flesh of the Coelacanth was soft, almost plastic. The specimen had by then been dead for at least twenty-four hours. From this one may deduce that the fish might be expected to have only flabby muscles. The soft cartilaginous chordal sheath might be regarded as confirmatory. At the same time I have found a small section of the adductor muscle, and that is firm and strong.

It seems fairly certain that this fish is hardly likely to have had powerful

propulsive muscles capable of sustained effort. At the same time it would probably be capable of high output of energy for a brief period, after the manner of the Lophiid fishes. Thus among rocks, where it could stalk and pounce upon its prey, it would be a formidable creature. Mr. J. Omer-Cooper has suggested that it might use the second dorsal and the anal fins in swimming, or to assist it in crawling about. That appears reasonable.

Oil.

It was reported by the taxidermist that about one pint (about 600 c.c.) of oil had run from this fish, also that the flesh was oily, and that the chordal tube was partly filled with it. In fact, the taxidermist stated that oil "spurted" out where the first incision was made into the chordal sheath. Unfortunately the oil was thrown away, so little can be said about its nature.

The remaining parts of the fish are certainly abnormally oily, and the skin is impregnated with oil. The structure of the skin shown in Plate XLIV suggests that the lower cancellate portion is composed of oil-cells.

Even the bones remaining are saturated with oil, especially those on or bearing sensory canals. Preliminary extraction with chloroform was necessary before alizarin staining could be carried out. The conditions of many of the t~~a~~bular bones indeed suggested that the sensory canal tubular system had been bathed in oil.

The oil is probably of food-storage function. The high oil content of this fish is significant in relation to the theory of the "animal" origin of the "mineral" oil deposits of the world.

Structures of Uncertain Identity.

Muscle Sheath (*P*) (Plates XXI and XXII; text-figs. 11 and 16).—This sheath was partly intact and had been stuffed by the taxidermist. I cannot give any positive information about its function. It probably contained some of the anterior optic musculature.

Palatine Canal (*W*) (text-fig. 7).—From the apex of the muscle sheath (P) there runs anteriorly a canal of moderate size. It lies on the skin of the roof of the mouth and runs almost straight forward beneath the wing of the parasphenoid, thus also beneath the ectethmoid (38) and the olfactory capsule, ending on the front margin of the upper jaw, above the dental plate of the prevomer. In view of its relation to muscle (P) it is a possible course for the following: buccal VII, palatine VII + palatine IX.

Habitat.

It is by no means easy to explain how the existence of this species has not previously been suspected. No fossil remains from Africa are related to it more closely than those from other parts of the world.

The problem is essentially that of habitat. Judging from its general structure, this fish has survived almost unchanged from at least the Triassic. During that period it has lived in such conditions as to have left no obvious fossil remains, *e.g.* it may be a member of the earliest marine branch which has always lived in the sea, and in those parts of the sea of which the bottom has suffered no permanent elevation above sea-level. Under those circumstances the possibility of the discovery of remains would be very remote.

The species can scarcely frequent ordinary muddy- or sandy-bottomed areas within the 200-fathom line on our coasts, since it would most likely have been previously captured by trawlers. It is possible, indeed very probable, that this has happened, one report received stating that six such fishes had been taken in one trawl off the Natal coast, but discarded as unknown vermin. It is, however, certain that Coelacanths are, if not unknown, at least very rare in the marine areas mentioned, since repeated captures would inevitably have been reported. It is also reasonably certain that this species does not frequent rocky areas within the 50-fathom line, or it must have been taken by lines. Again there is the possibility that this has occurred. Our line fishermen are notoriously superstitious, and much opposed to pulling into the boat any strange creature. Still, the evidence is against there having been many captures of this Coelacanth by the line-boats of South Africa, which rarely operate at depths exceeding 40 fathoms.

Opinions have been advanced that this species is a wanderer from the depths of the ocean. Dr. White, of the British Museum, in a popular article (Illustrated London News, 1939, vol. cxciv, No. 5212, Supplement, text) advanced the opinion that "Our living Coelacanth almost certainly was a wanderer from the deeper parts of the sea to which its kind have retreated in the face of fierce competition with the more active modern types of fishes." A number of facts are in conflict with that opinion. This is no degenerate fish. It is obviously a predaceous carnivorous form, at least as agile and dangerous as some of the more sluggish fishes, such as the larger Serranids, which occur on our eastern shores. It is probably more of a "pouncer" than a speedy pursuer.

Against the bathybial habit may be ranged some degree of annulation in the circuli of the scales, the heavy squamation, and the eye of normal size. No bathybial form, not even those from only three hundred fathoms,

could possibly survive removal from the water by three to four hours, certainly not after having undergone compression and damage in the bag of the trawl net, and on the deck of the trawler under a few tons of other fishes. The weight of the evidence points to a habitat of moderate depth beyond the reach of line fishing, and with bottom conditions such that trawl nets cannot operate. This suggests rocky areas probably at depths of 80–150 fathoms, where the Coelacanths possibly crawl as much as swim, and stalk their prey.

It has earlier been indicated that there are grounds for suspecting that the Coelacanths may live on the rocky or ridged outer edge of the 40–60-fathom shelf which lies off parts of our eastern coast. It is not unlikely that as a result of the publicity attending the discovery of this specimen others will be brought ashore before very long. At the same time should my guess about the habitat have any foundation in fact, the capture of other specimens will remain a matter of chance, at least in so far as ordinary commercial fishing is concerned. On any rocky slope trawling is out of the question. In even still water line-fishing at depths of 100–200 fathoms would be of doubtful value, and uncertain. The strong current which runs in the area where the Coelacanthids are supposed to occur would render this next to impossible of operation. The Mozambique current flows there from the north-east at an average rate of 2·5–3 knots, often at a greater speed. Such a current renders bottom line-fishing at even 40 fathoms very difficult. The technical difficulties at 100 fathoms would be very great.

Since some archaic survivals among fishes are located in fresh waters, at least the possibility of that habitat for the Coelacanth should be considered. Had this fish come from fresh water it must have come *via* one of the neighbouring tidal rivers. Those that may be considered are the Kei, the Buffalo, and the Chalumna rivers, less likely the Fish and the Keiskama rivers, since the latter are relatively distant and downstream of the Mozambique current. In the Kei and Buffalo rivers are fairly long stretches of water of low salinity within the effect of the tides. It is just possible that not very plentiful and wary large fishes might manage to live there in comparative obscurity. They might secure sufficient food by raiding the more abundant marine life of the estuaries. It is, however, extremely unlikely that any large fishes could live in those conditions and remain unknown to the natives at least.

The inland waters of the rivers of the eastern Cape can scarcely be considered a possible habitat. They consist chiefly of a series of disconnected pools, whose scanty fauna would not provide sufficient food for such large fishes as the Coelacanth. Also no such large fish could possibly lurk unknown there.

It would be unlikely for a freshwater form to enter the sea, to descend as deep as 40 fathoms and to remain alive with apparently unimpaired vitality (shown by its living for $3\frac{1}{2}$ hours after removal from the water).

It may be considered extremely unlikely that this Coelacanth was a wanderer from a freshwater habitat.

I wish to express my gratitude to Dr. Stensiö, Dr. Westoll, Dr. Moy-Thomas, and Dr. Nielsen for gifts of their valuable works. Especially to Dr. Westoll for kindly undertaking the laborious work of correcting the proofs of this paper. To Mr. Norman of the British Museum for kindly correcting the proofs of preliminary papers. To Miss Lyle ~~and~~ To Mr. Omer-Cooper for having placed at my disposal all the resources of the Zoological Department of this College, and to Professor E. D. Mountain for preparing sections of a tooth, and for helpful suggestions about its structure. To Mr. J. Sebba, B.Sc., for preparing and photographing the sections of a scale and of the skin, also for assisting with a part of the other photography. Also to numerous friends for assistance in the great labour involved in numbering of structures in figures and in checking the manuscript.

I am indebted to the National Research Council of South Africa for generous financial assistance (Carnegie Fund).

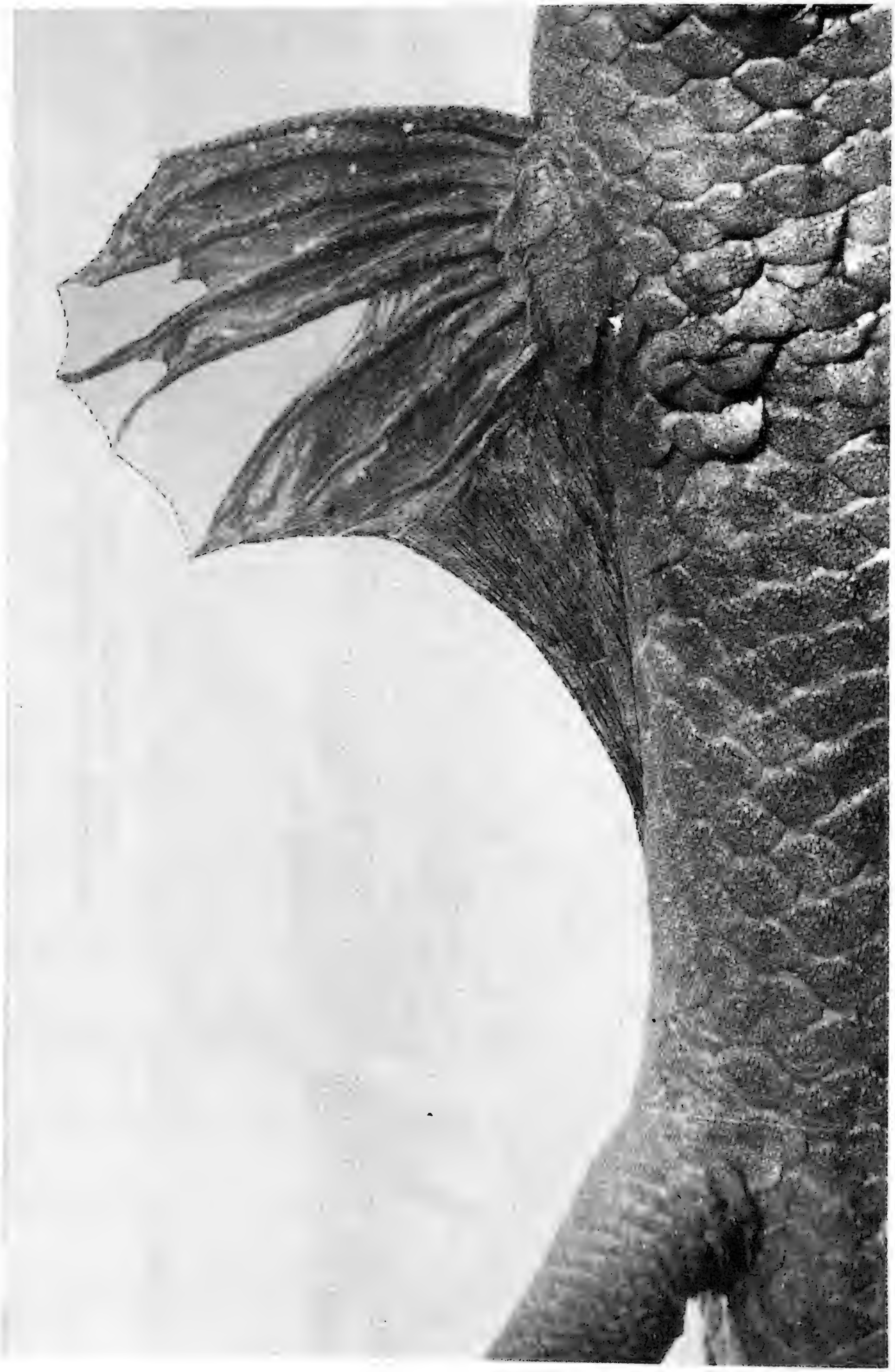
RHODES UNIVERSITY COLLEGE,
GRAHAMSTOWN,
June 1939.

and to Mr Ruddock for their interest in preparing scale sections.

The Council desires to acknowledge the receipt of a grant from the National Research Council and Board towards the cost of publication of this paper.

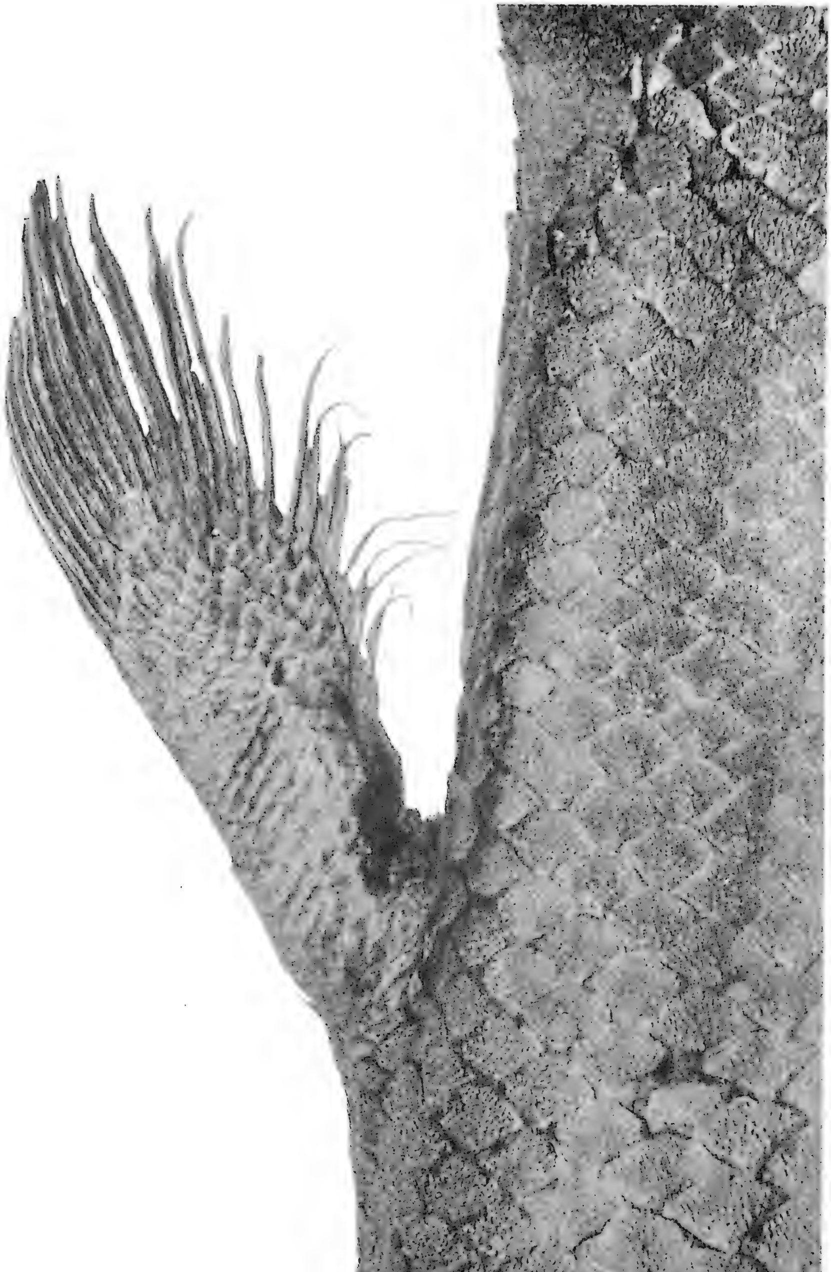
Latimeria chalumnae Smith. ×0·125.
The small arrow shows the position of the spiracle.

J. L. B. Smith. *Neill & Co., Ltd.*



Latimeria chalumnae Smith.
First dorsal fin with membranes restored, from right side. ×0·42.

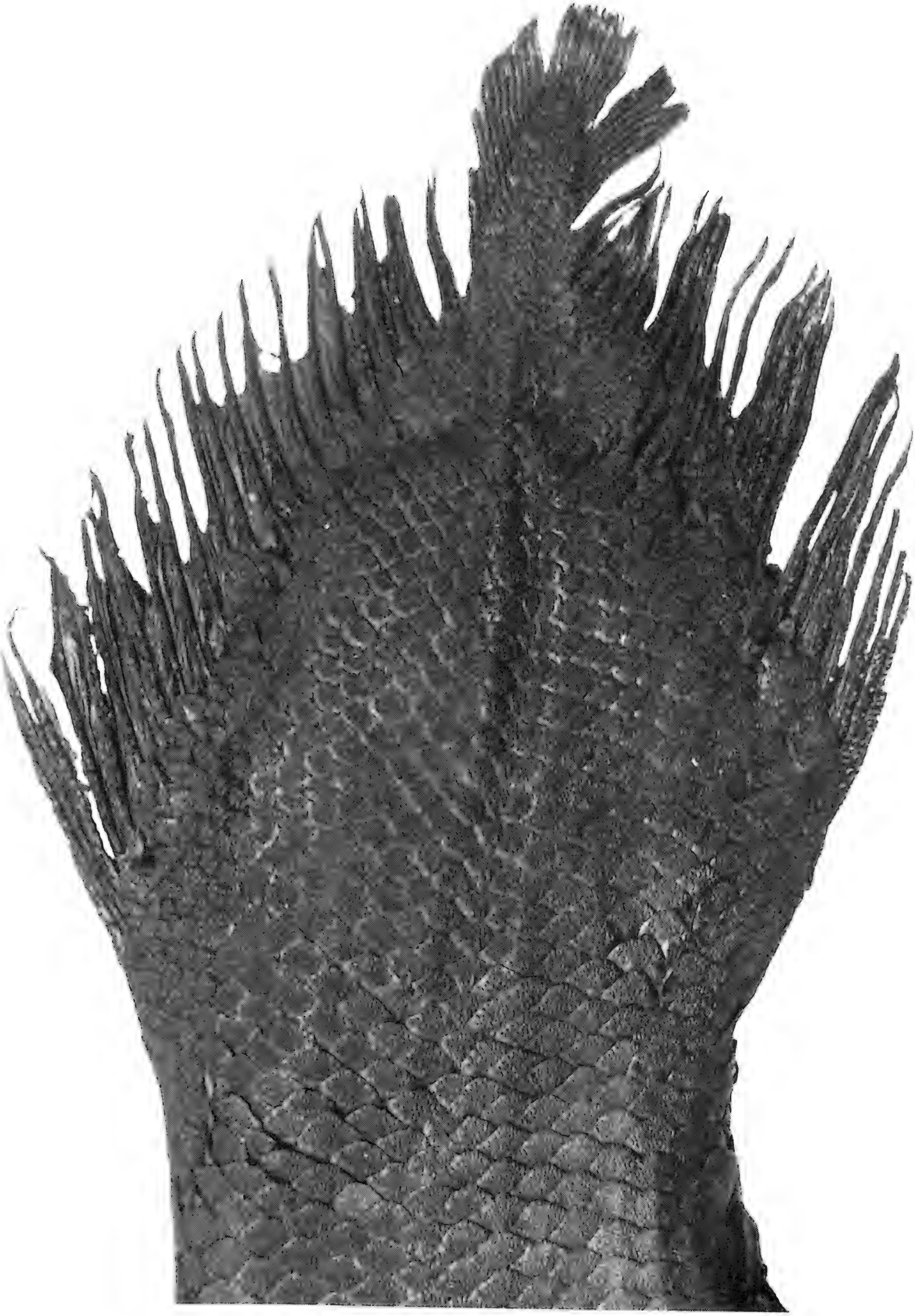
J. L. B. Smith. *Neill & Co., Ltd.*



Latimeria chalumnae Smith.

Second dorsal fin. ×0·5, showing some of the scaling. The small arrow shows the lateral line.

J. L. B. Smith. Neill & Co., Ltd.



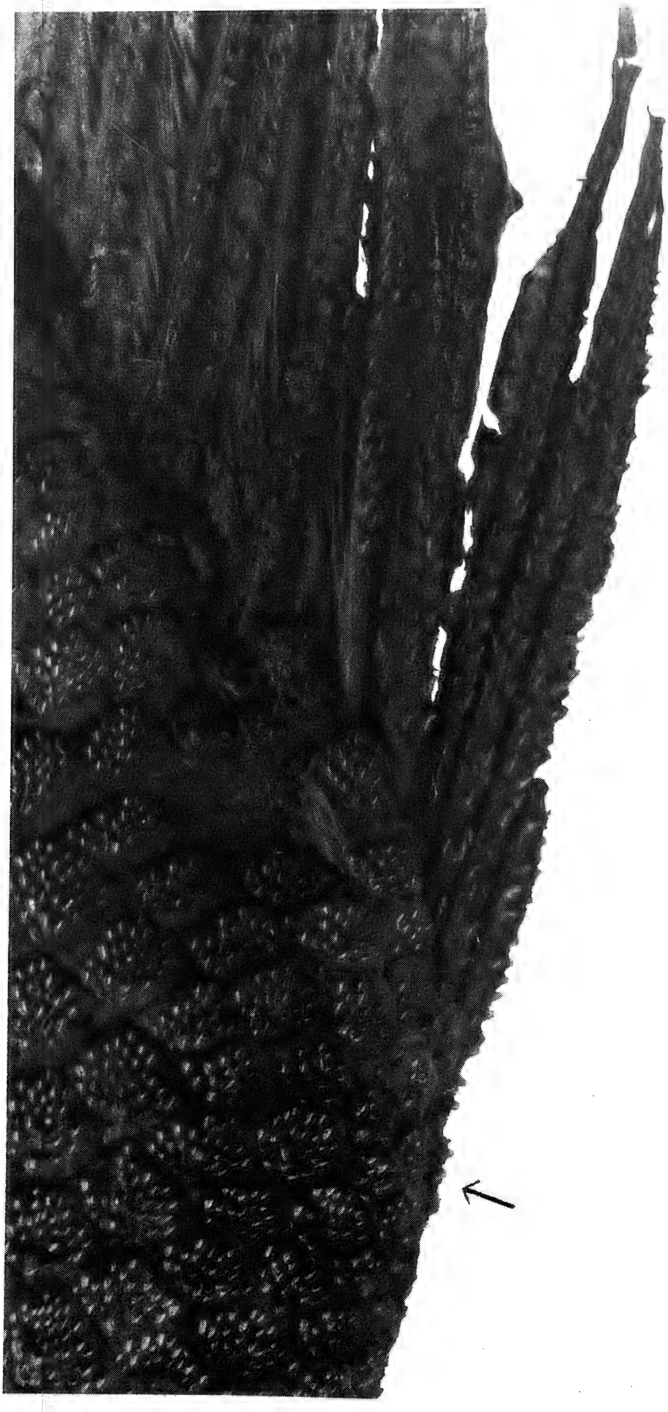
Latimeria chalumnae Smith. Caudal fin, left side. ×0·36.

J. L. B. Smith.

Neill & Co., Ltd.

Supplementary caudal fin, left side. × 1·04.

J. L. B. Smith. Neill & Co., Ltd.



Latimeria chalumnae Smith. Anterior principal ventral caudal rays. × 1·4, showing some of the caudal scaling.
The small arrow shows the first short ray.

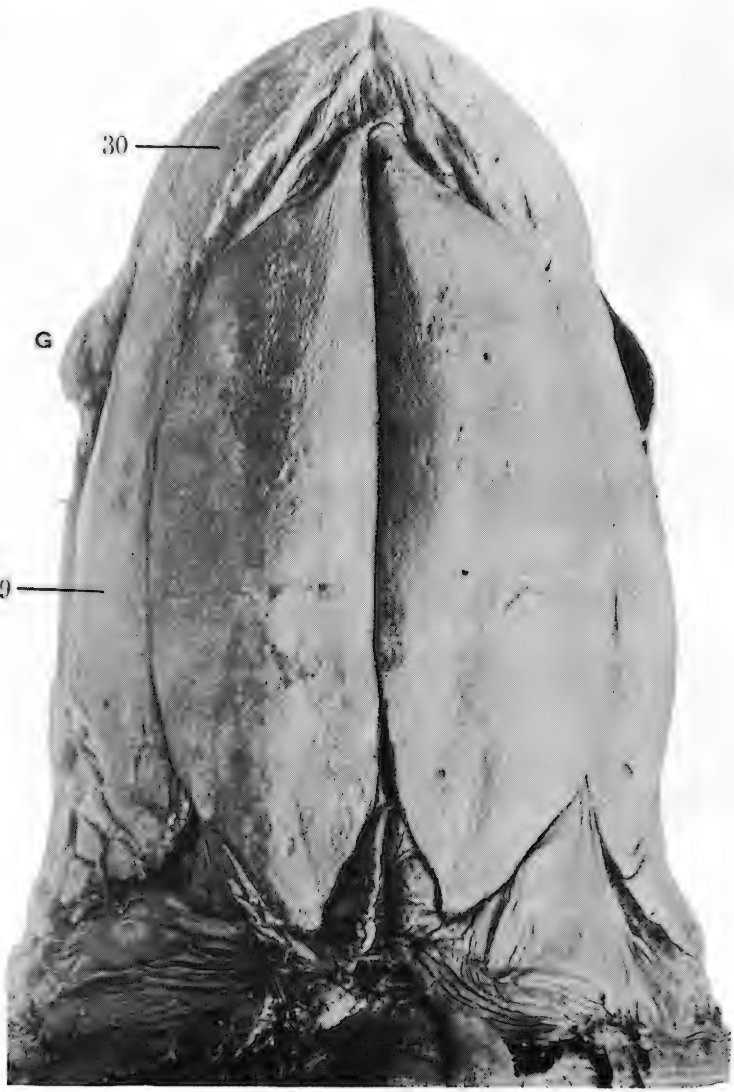
J. L. B. Smith.

Neill & Co., Ltd.

Latimeria chalumnae Smith.
Side view of snout. ×0·6. For explanation see Folder-page I at end.

Latimeria chalumnae Smith.
Right pectoral fin. ×0·35.

Latimeria chalumnae Smith.
Left pelvic fin. ×0·6.

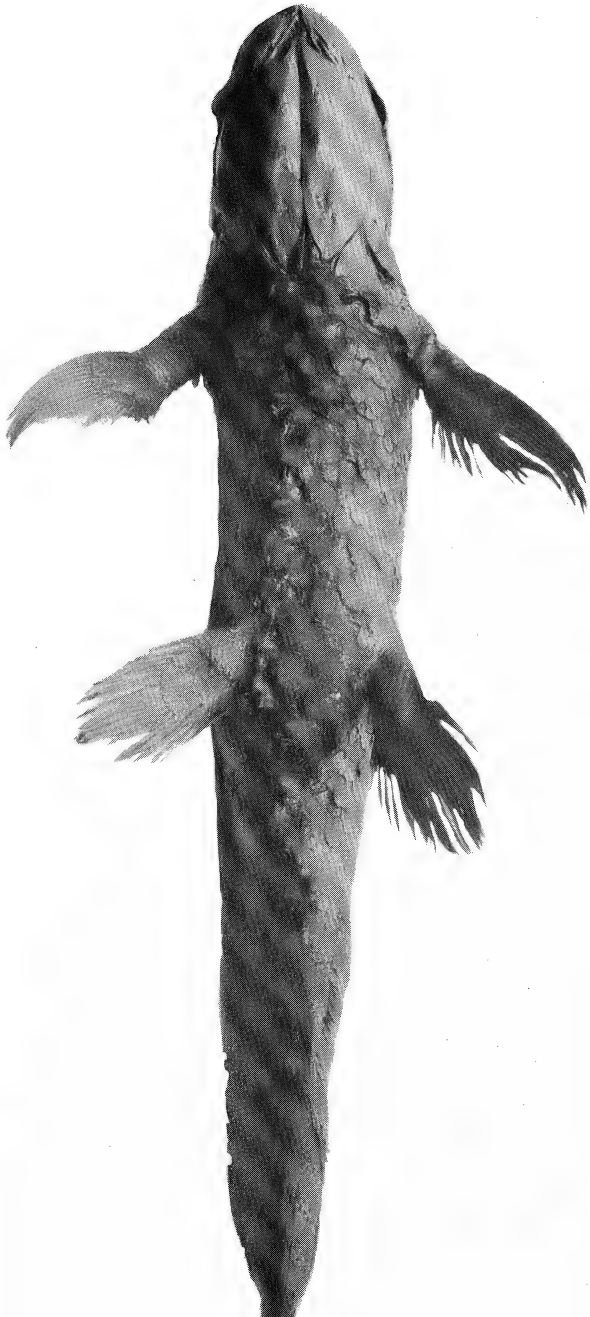


Latimeria chalumnae Smith.
Ventral view of head showing gular plates. × 0·45. For explanation see Folder-page I at end.

Latimeria chalumnae Smith.
Dorsal view of head. ×0·55.

J. L. B. Smith. *Neill & Co., Ltd.*

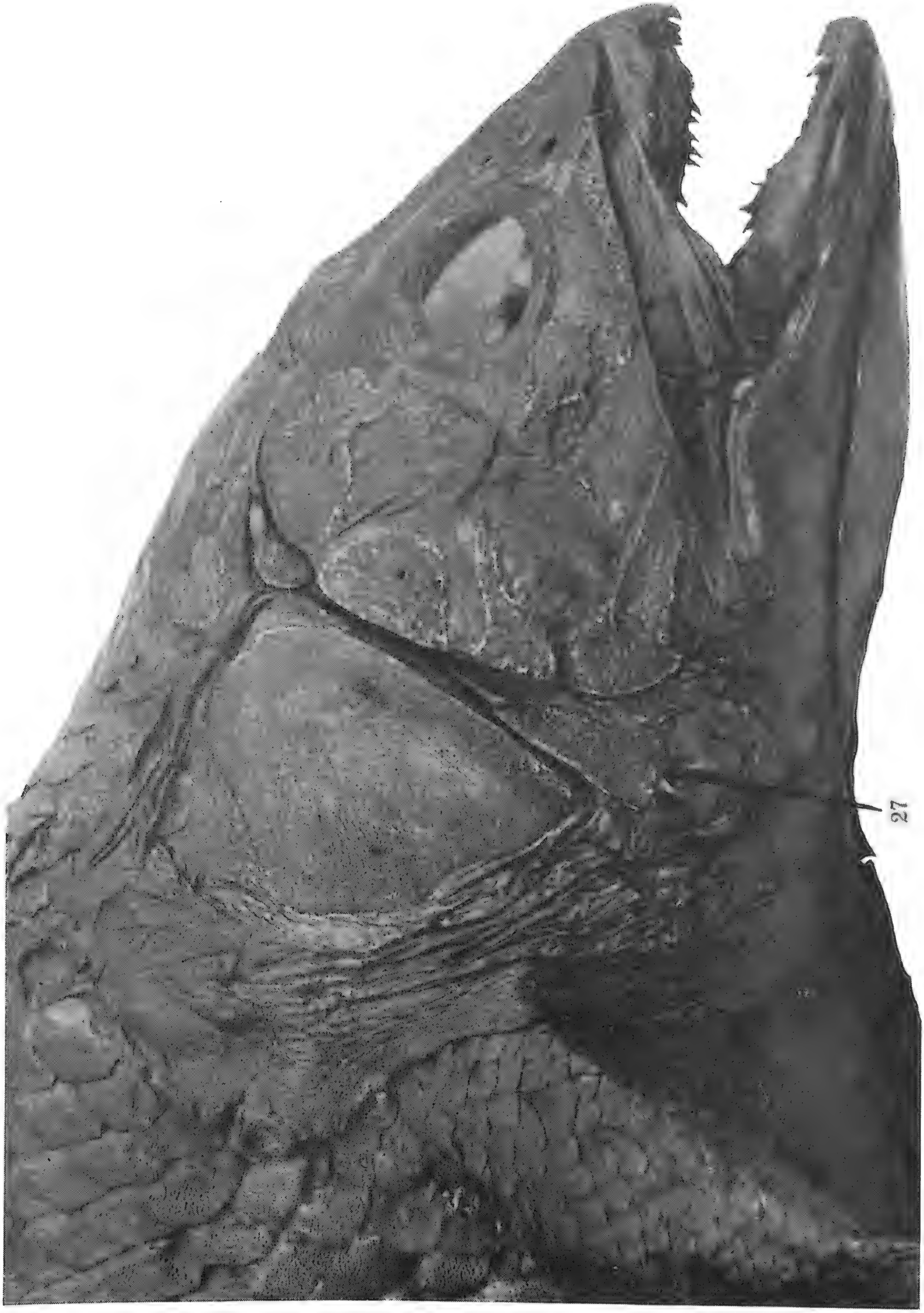
Latimeria chalumnae Smith.
Front view of head. ×0·6. For explanation see Folder-page I at end.



Latimeria chalumnae Smith. Ventral view. ×0·125.

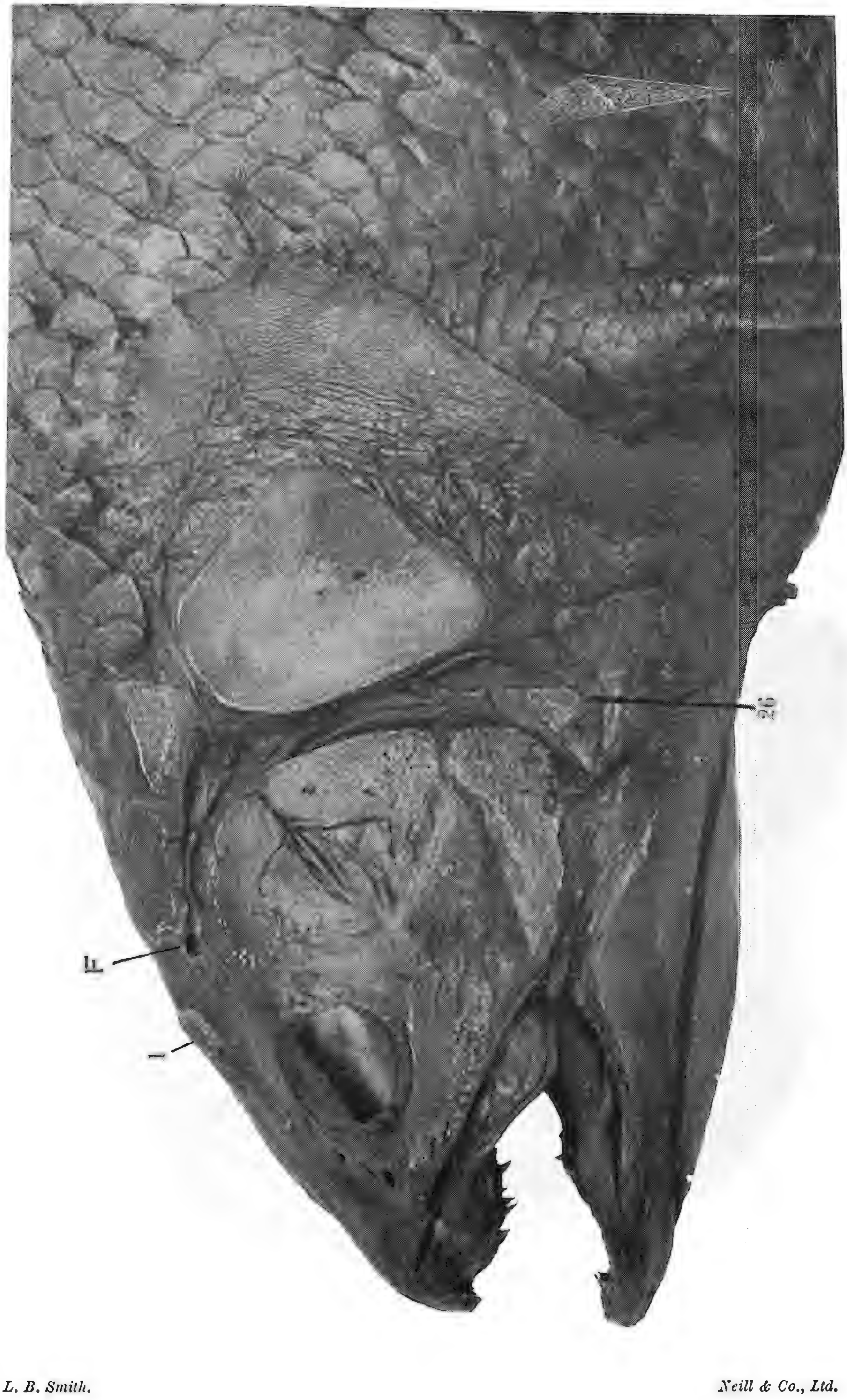
J. L. B. Smith.

Neill & Co., Ltd.



Latimeria chalumnae Smith. Head, right side. ×0·45. For explanation see Folder-page I at end.

J. L. B. Smith. Neill & Co., Ltd.



Latimeria chalumnae Smith.

Head, left side. ×0·39. (See text-fig. 5.) For explanation see Folder-page I at end.

Latimeria chalumnae Smith.

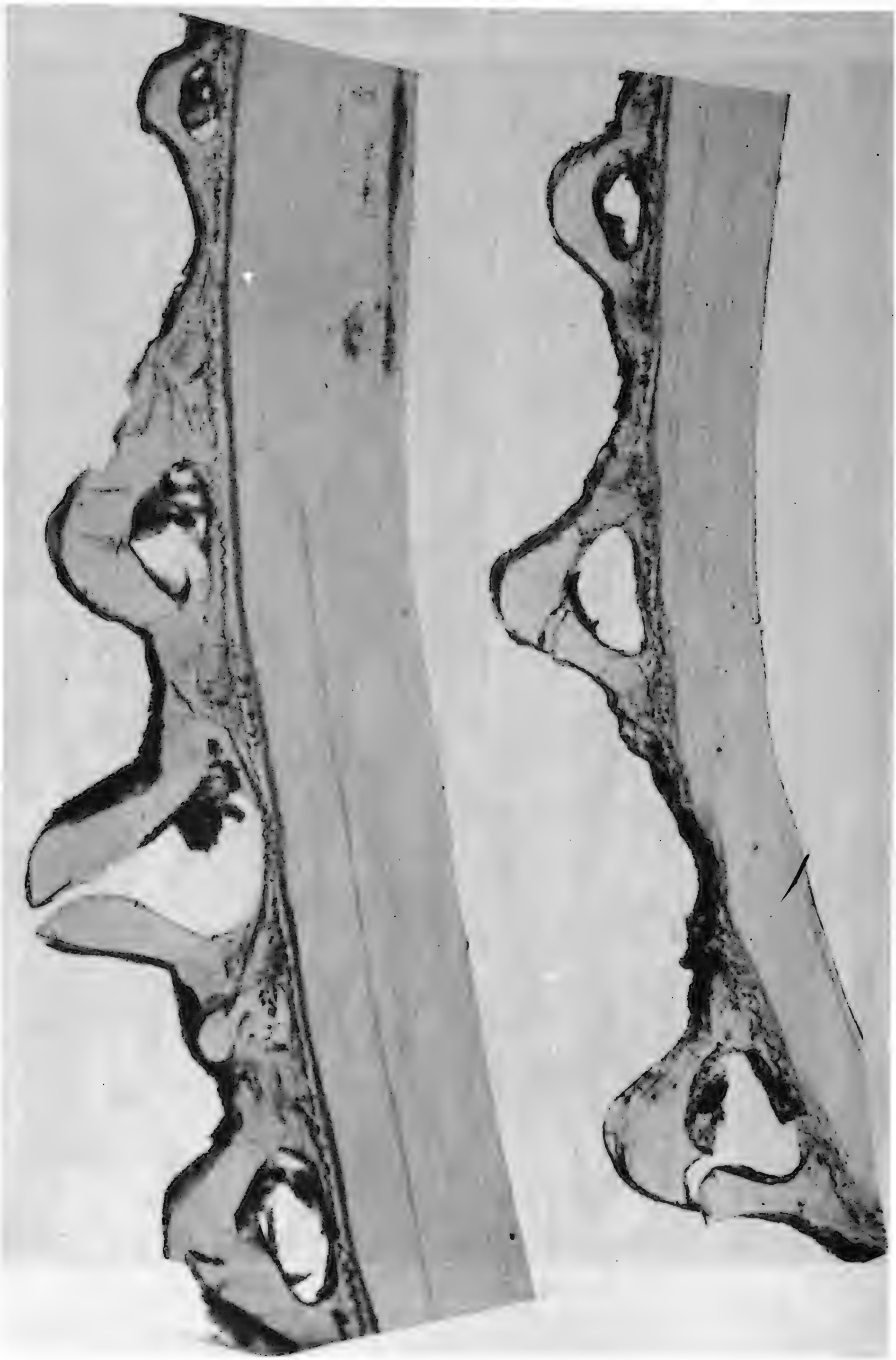
Left : Reverse side of suborbital showing foramina. The bent wires are pushed into smaller foramina.
Top centre : Reverse side of postorbital. Remaining are cheek-bones orientated, all ×0·83. For explanation see Folder-page I at end.

Latimeria chalumnae Smith.
Left side of head with lateral dermal bones and parafrontal series removed. ×0·39. (See text-fig. 11.)
For explanation see Folder-page 1 at end.

Latimeria chalumnae Smith.
Scales: All × 1·4. See Folder-page II at end.

J. L. B. Smith.

Neill & Co., Ltd.



Latimeria chalumnae Smith.
Sections of a scale from the upper portion of the caudal peduncle (78). Upper ×65; lower ×48.
See Folder-page II at end.

J. L. B. Smith. *Neill & Co., Ltd.*

Latimeria chalumnae Smith.
Section of skin from cheek, ×75. Outer surface above.

J. L. B. Smith.

Neill & Co., Ltd.

FOLDER-PAGE I.

Key to Plates and Text-figures.

OSSIFICATIONS.

1. Frontal.
1′. "Alisphenoid."
2. Frontal.
3. Fronto-nasal.
4. Postrostral.
5. Naso-antorbital.
6. Rostro-nasal.
7, 7′. Rostral.
Interrostral 8. Meso-rostral.
9, 10. Rostral.
11, 12, 13, 14, 15, 16. Parafrontal.
17. Parafronto-antorbital.
18. Latero-rostro-nasal.
19. Rostral.
20. Inner-rostral.
21. Mid-rostral.
22. Outer-rostral.
23. Postorbital.
24. Squamosal.
25. Preopercular.
26. Interopercular.
27. Subopercular.
28. Opercular.
29. Angular.
30. Splenial.
31. Gular.
32. Articular.
33. Pterygoid.
34. Quadrate.
35. Metapterygoid.
36. Ectopterygoid.
37. Autopalatine.
37″. Autopalatine dental plate. (dermopalatine)
38. Ectethmoid.
39. Symplectic.
40. Precoronoid.
41. Coronoid.
42. Antotic process of basisphenoid.
43. Articular-prearticular.
44. Dentary.
44″. Dental plates of dentary.
45. Copula.
46. Labial tooth plate.
47. Quadrato-jugal.
48. Lacrimo-jugal (suborbital).
49. Intertemporal.
50. Supratemporal.
50′. Inferior antrorse process of the supra-temporal.
51. Postspiracular.
52. Parasphenoid.
52″. Dental plate of parasphenoid
53. Prevomer.
53″. Dental plate of prevomer.
54. Entopterygoid.
55. Inter-extrascapular.
56. 1st extrascapular.
57. 2nd extrascapular.
58. 3rd extrascapular.
59. Outer-extrascapular.
60. 1st lateral line scale.
61–88. Scales (see Folder-page II).
89. Suprapterygoid denticulate area.
90. Rostral dental plates.
91. Postrostral dental plate.
92. Prootic ossicle.
93. Prootic.
94. Hyomandibular ossification.
94′. Hyomandibular upper cartilage.
94″. Hyomandibular lower cartilage.
95. Bony stud on nape.
96. Basisphenoid.
97. Cleithrum.
98. Clavicle.
99. Extracleithrum.
100. I. Articulation facet for ceratohyal on basihyal.
II. Articulation facet for urohyal on basihyal.
III. Articulation facet for basibranchial on basihyal.

OTHER STRUCTURES.

A. Rostral narial aperture and tube.
B. Lower lateral narial aperture and tube.
C. Upper lateral narial aperture and tube.
D. Rostral papilla.
E. Olfactory capsule.
F. Spiracle.
G. Pseudo-maxillarial fold.
H. Hyoidean gill-slit.
J. Tube, foramen, or sheath for ophthalmic branches of the V and VII nerves.
K. Cartilage.
L. Olfactory lobes of the brain.
M. Brain cavity.
N. Eye.
O. Adductor fossa.
P. Muscle.
Q. Branchial arches (I–IV).
R. Ethmoidal nasal cavity.
S. Skin.
T. Lateral spiracular groove.
U. Spiracular pouch.
V. Antotic cavity.
W. Palatine canal.
X. Mandibulary labial fold.
Y. Dentate skin fold from hyomandibular.
Z. Median ridge from clavicle articulation to symphysis.

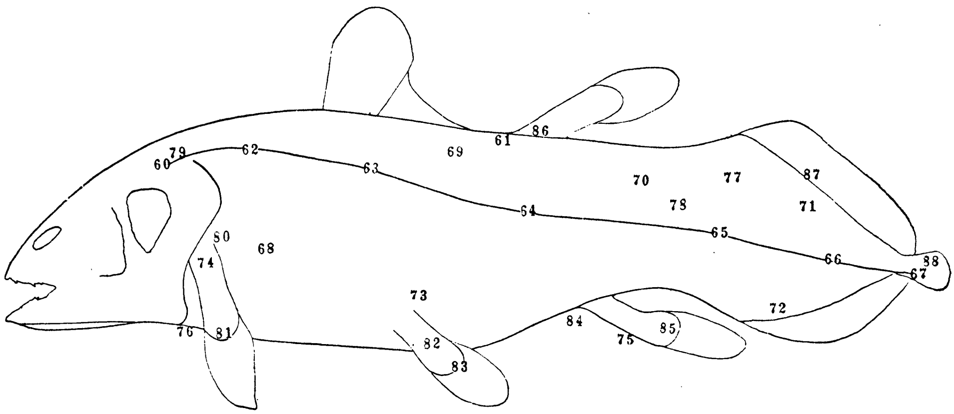
SENSORY CANALS.

a. Parafrontal canal.
b. Infraorbital canal.
d. Jugal canal.
e. Mandibulary canal.
f. Supratemporal canal.
g. Rostral commissural canal.
h. Posterior rostral commissural canal.
q. Preopercular canal.
r. Fronto-rostral commissural canal.
t. Supratemporal commissural canal.

FOLDER-PAGE II.

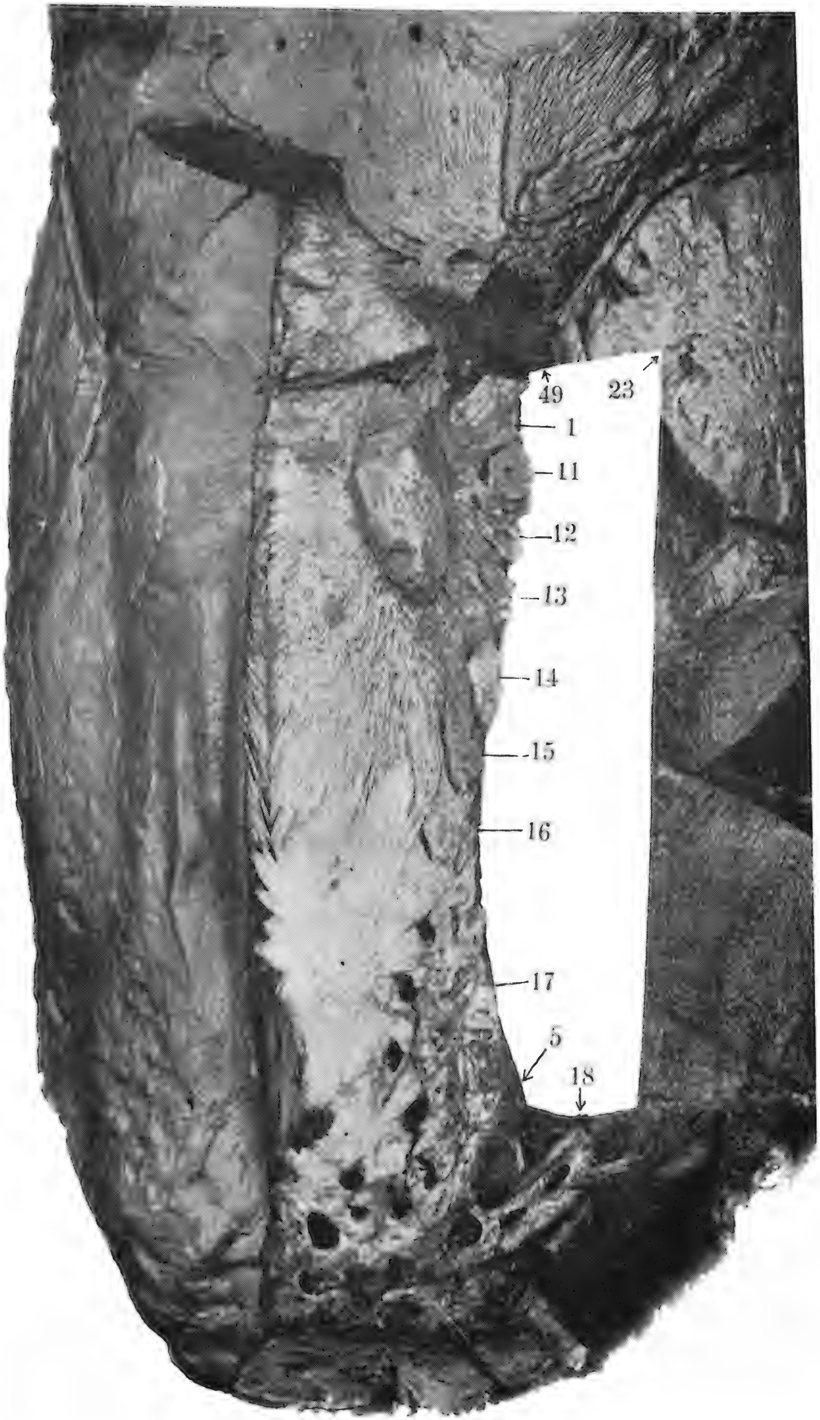
SCALES.

Key to Plates XXXII–XLII inclusive.



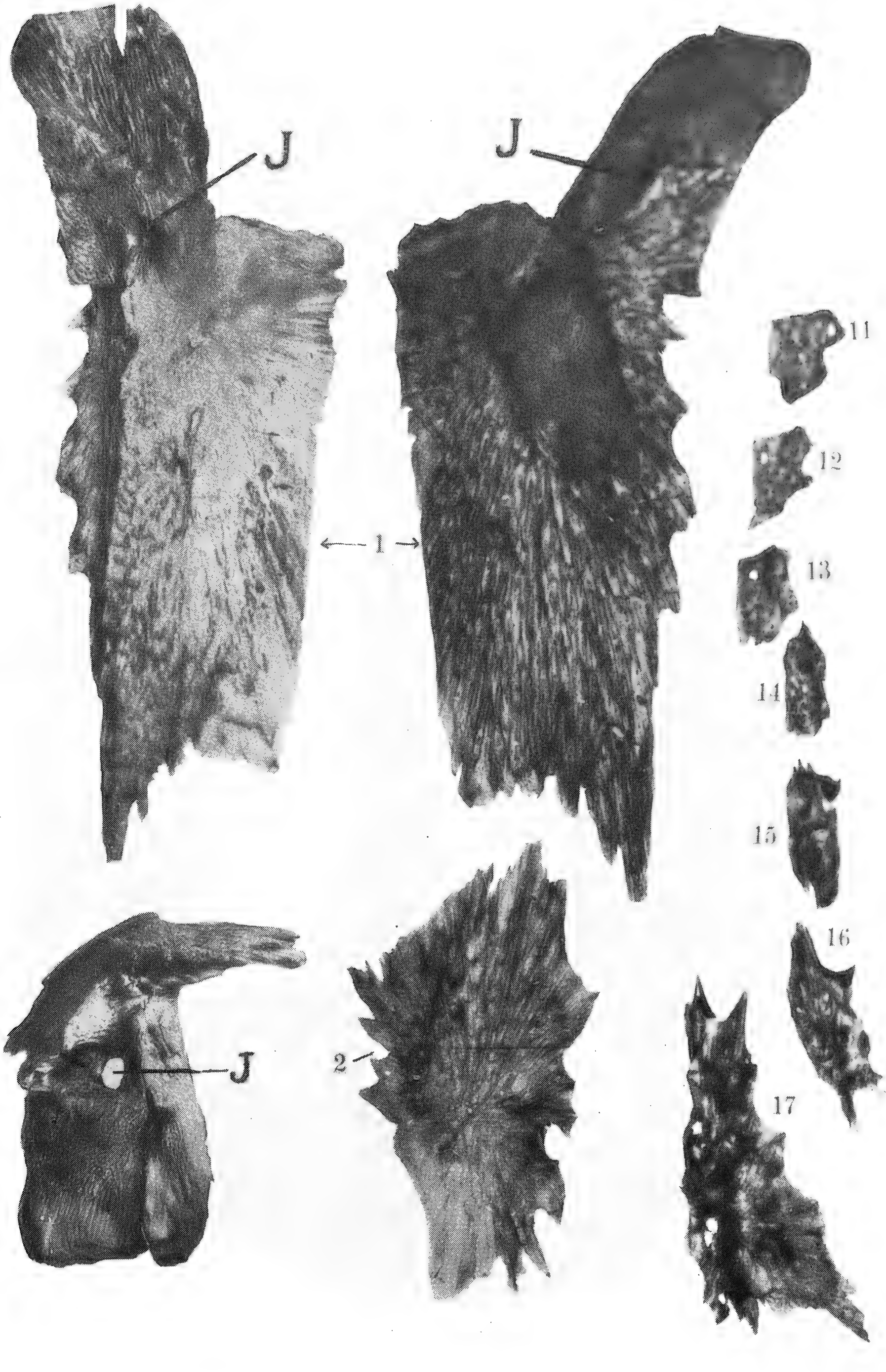
TEXT-FIG. 20.—*Latimeria chalumnae* Smith. To show the approximate positions from which figured scales have been taken.
Unless otherwise stated, scales are from the left side of the fish.

60. 1st lateral line.
61. Base, 2nd dorsal, right side.
62. 9th lateral line.
63. 18th lateral line.
64. 34th lateral line.
65. 51st lateral line.
66. 64th lateral line.
67. 88th lateral line.
68. 5th row below lateral line, behind pectoral base.
69. 4th row above lateral line, interdorsal.
70. 4th row above lateral line, behind second dorsal.
71. 8th row above lateral line, below 9th caudal ray.
72. 10th row below lateral line, above 6th caudal ray.
73. 7th row below lateral line, behind pelvic base.
74. Upper lateral face of pectoral limb.
75. Anterior face of anal peduncle.
76. Anterior mid-breast.
77. Tubercle from scale below dorsal caudal rays.
78. Sections of scale from above lateral line on peduncle.
79. 2nd lateral line.
80. Axil of pectoral.
81. Base of mid-rays of pectoral.
82. Middle of dorsal face of limb of pelvic.
83. Base of mid-rays of pelvic.
84. Mid-ventral, just anterior to anal insertion.
85. 3rd scale up from base of mid-rays of anal.
86. 2nd dorsal base, lateral.
87. Base of dorsal, 9th principal caudal ray.
88. Dorsal end of supplementary caudal.



Latimeria chalumnae Smith.
Dorsal view of fronto-rostral area with skin removed on left side. ×0·88.
(Compare text-fig. 3.) For explanation see Folder-page I at end.

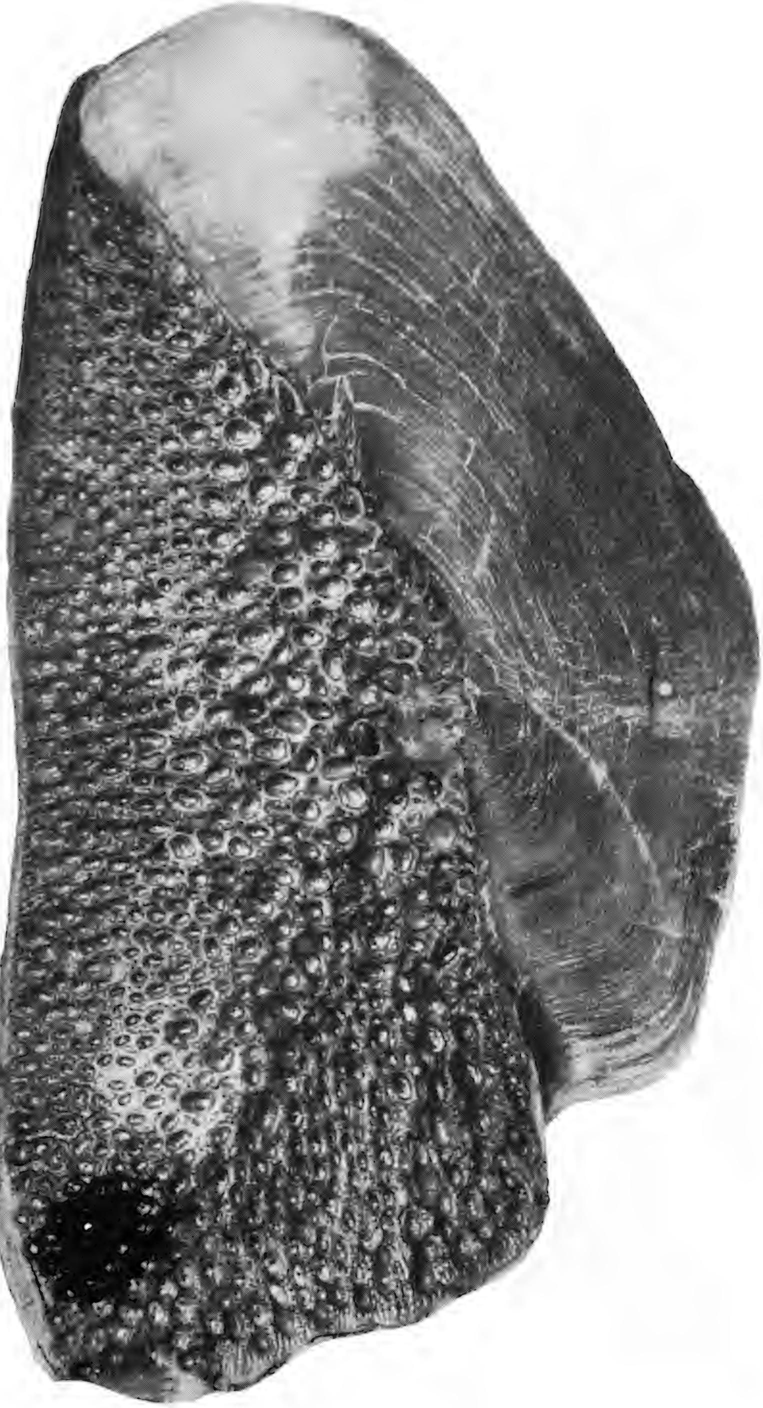
J. L. B. Smith. *Neill & Co., Ltd.*



Latimeria chalumnae Smith. Fronto-rostrals. × 1·14.
Left, above: Lower surface of frontal (1).
Left, below: Dorsal view of alisphenoid (1′). The cross shows position of sensory canal foramen.
For explanation see Folder-page I at end.

Latimeria chalumnae Smith. Rostro-nasals. × 1·9.
For explanation see Folder-page I at end.

J. L. B. Smith. *Neill & Co., Ltd.*



Latimeria chalumnae Smith.
Right subopercular (27). ×3.

J. L. B. Smith.

Neill & Co., Ltd.

Latimeria chalumnae Smith.
Left side of head showing nasal cavities. × 1·13. The two matches pass through the tubes from the lateral narial openings and show in the median sinus.
For explanation see Folder-page I at end.

J. L. B. Smith. *Neill & Co., Ltd.*

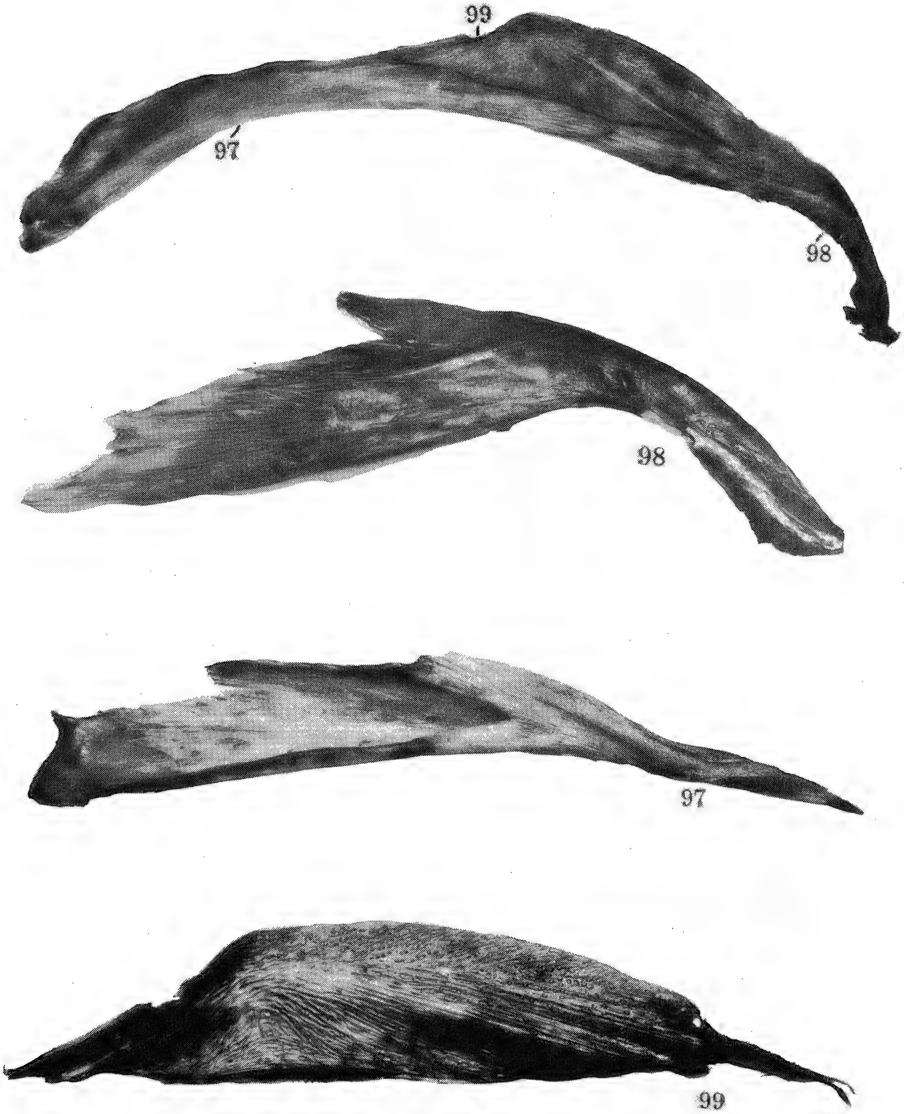
Latimeria chalumnae Smith.
Copula (45), dorsal. × 1·5.

Latimeria chalumnae Smith.
Copula (45), ventral. ×1·45.
For explanation see Folder-page I at end.

Latimeria chalumnae Smith.

Ramus of lower jaw, left side ×0·74. The arrow indicates the position and angle of entry of mandibulary canal. The white blotch below the arrow-head marks the hind end of the hinder branch of the canal. For explanation see Folder-page I at end.

Latimeria chalumnae Smith.
Left opercular, × 1·1. The hole among the tubercles is artificial.



Latimeria chalumnae Smith.

Above : External view of shoulder girdle complex, ×0·45.

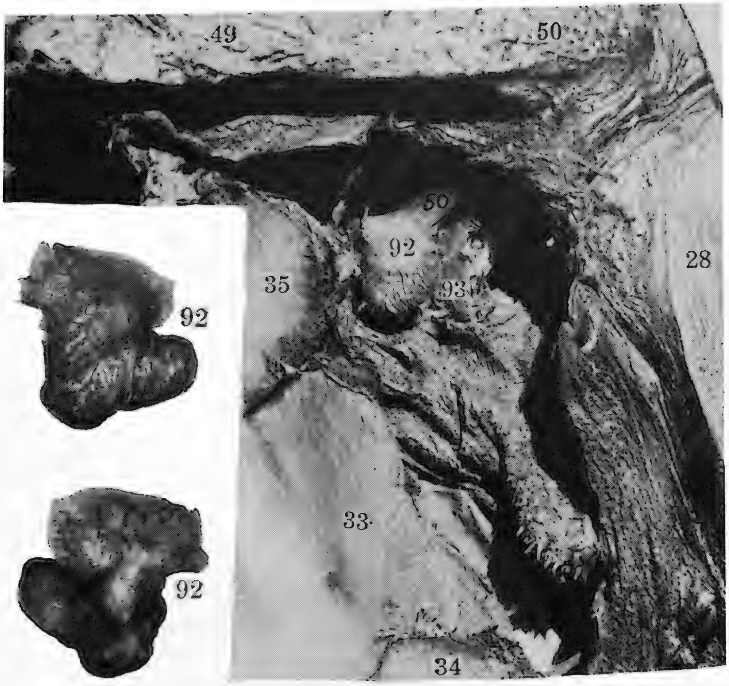
98. Clavicle alone, ×0·9. 97. Cleithrum alone, ×~~0·6~~. Inner view. Extracleithrum alone, ×1·0.

(See text-fig. 1.)

×0·8

J. L. B. Smith. *Neill & Co., Ltd.*

Latimeria chalumnae Smith.
Palatal roof ossifications from above, slightly left. Natural size.
For explanation see Folder-page I at end.

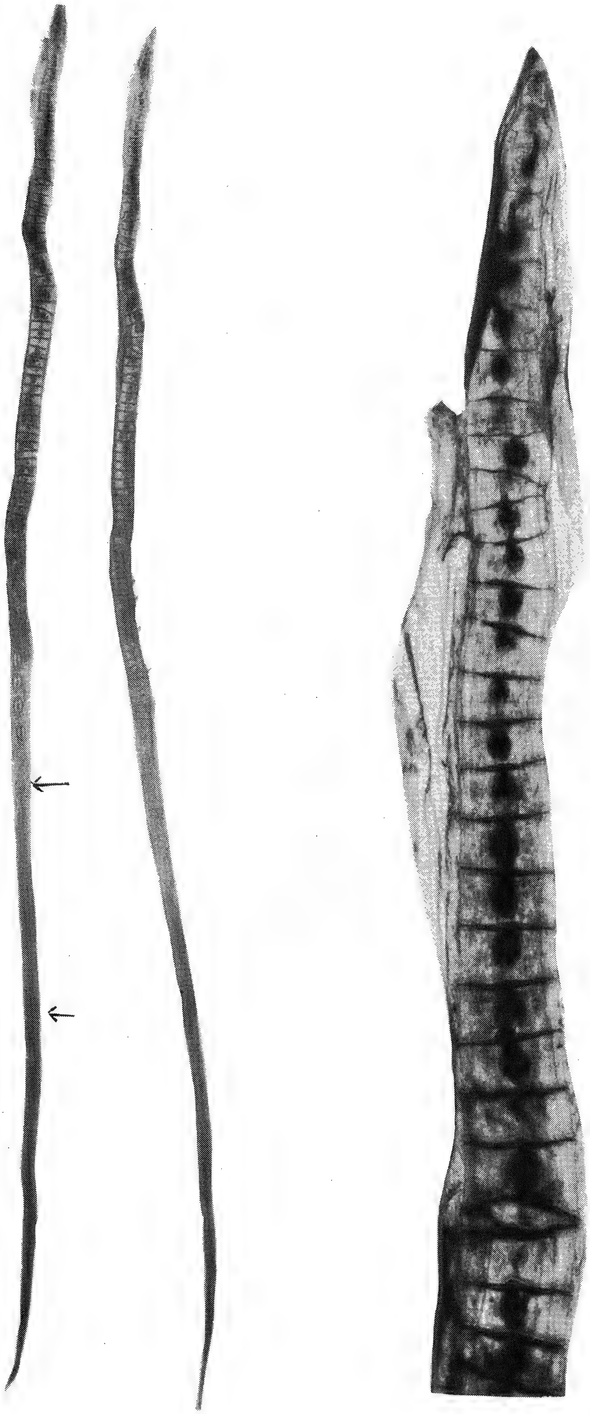


Latimeria chalumnae Smith.

Temporal region. Upper, ×0·87. Lower, ×0·7. *Inset on left*, antotic ossicle (92), ×1·3; *upper :* Exterior view, *lower :* View of base. For explanation see Folder-page I at end.

J. L. B. Smith.

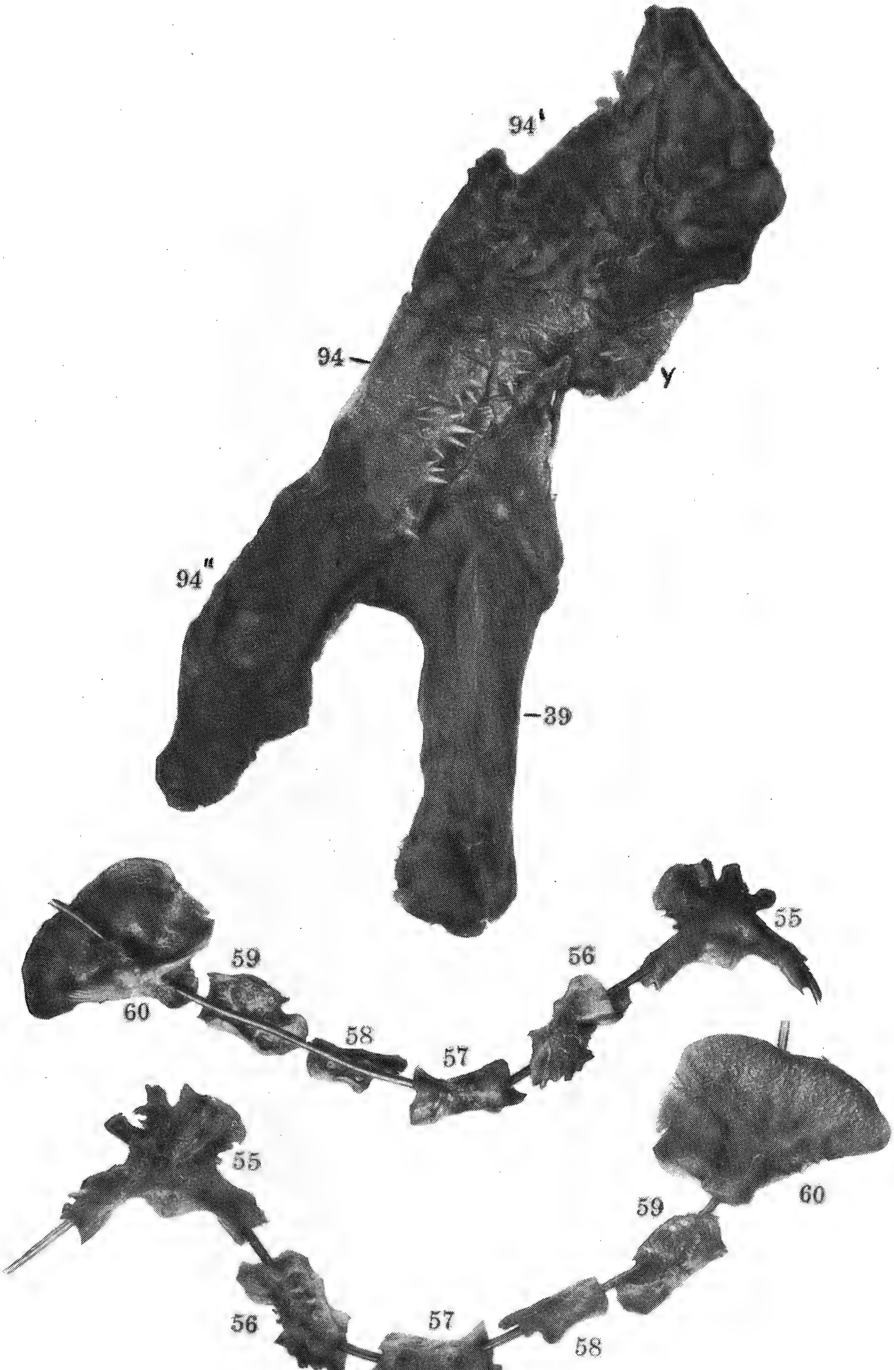
Neill & Co., Ltd.



Latimeria chalumnae Smith.

19th lepidotrich of ventral principal caudal. *On left:* two lateral segments, ×1·45. The upper arrow marks where the ray emerges from the body. The lower marks the point to which articulations are clearly visible. *On right:* upper portion of segment, ×8·2.

J. L. B. Smith. *Neill & Co., Ltd.*



Latimeria chalumnae Smith.

39–94. Hyomandibulary system from within, ×0·85. (See text-fig. 13.) 55–60. Extrascapulary chain. *Upper:* Ventral view, ×1·0. *Lower:* From above, ×1·15. The connecting wire shows the course of the canal. For explanation see Folder-page I at end.

J. L. B. Smith. Neill & Co., Ltd.

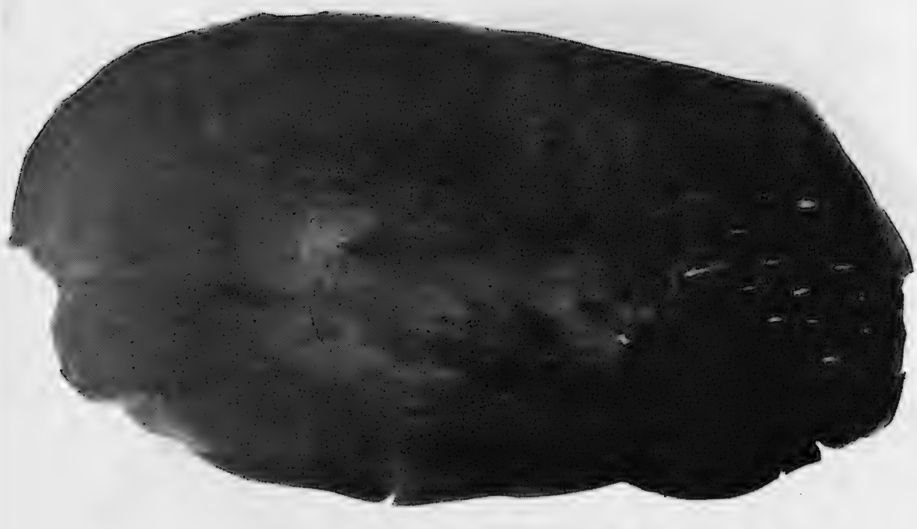
Latimeria chalumnae Smith.

Above : Section through second rostral plate (90), ×12. Anterior margin to the left. The outline below the small arrows is exposed outside the skin.

Below : Lateral view of postspiracular ossicle (51), ×3·8. Anterior margin to the left.

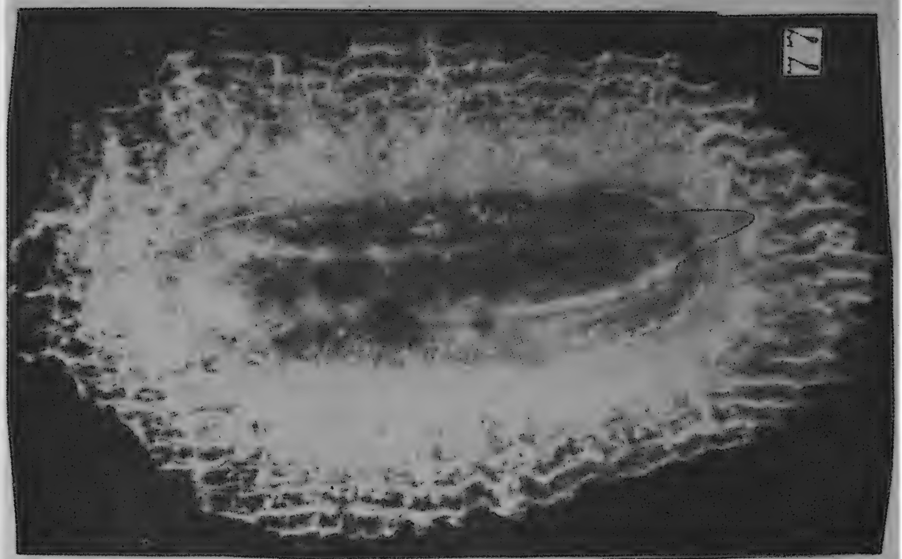
Latimeria chalumnae Smith.
71. 8th row above lateral line below 9th caudal ray (dorsal), ×4·3.
72. 10th row below lateral line above 6th caudal ray (ventral), ×3·4.
See Folder-page II at end.

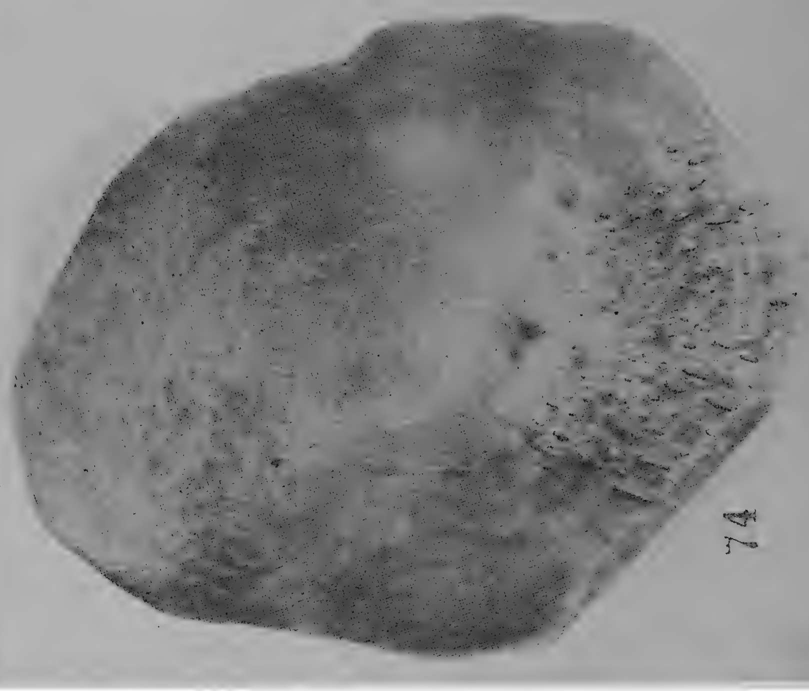
65



66

Latimeria chalumnae Smith.
66. 64th lateral line scale, ×4·3. 65. 51st lateral line scale, ×3.
See Folder-page II at end.



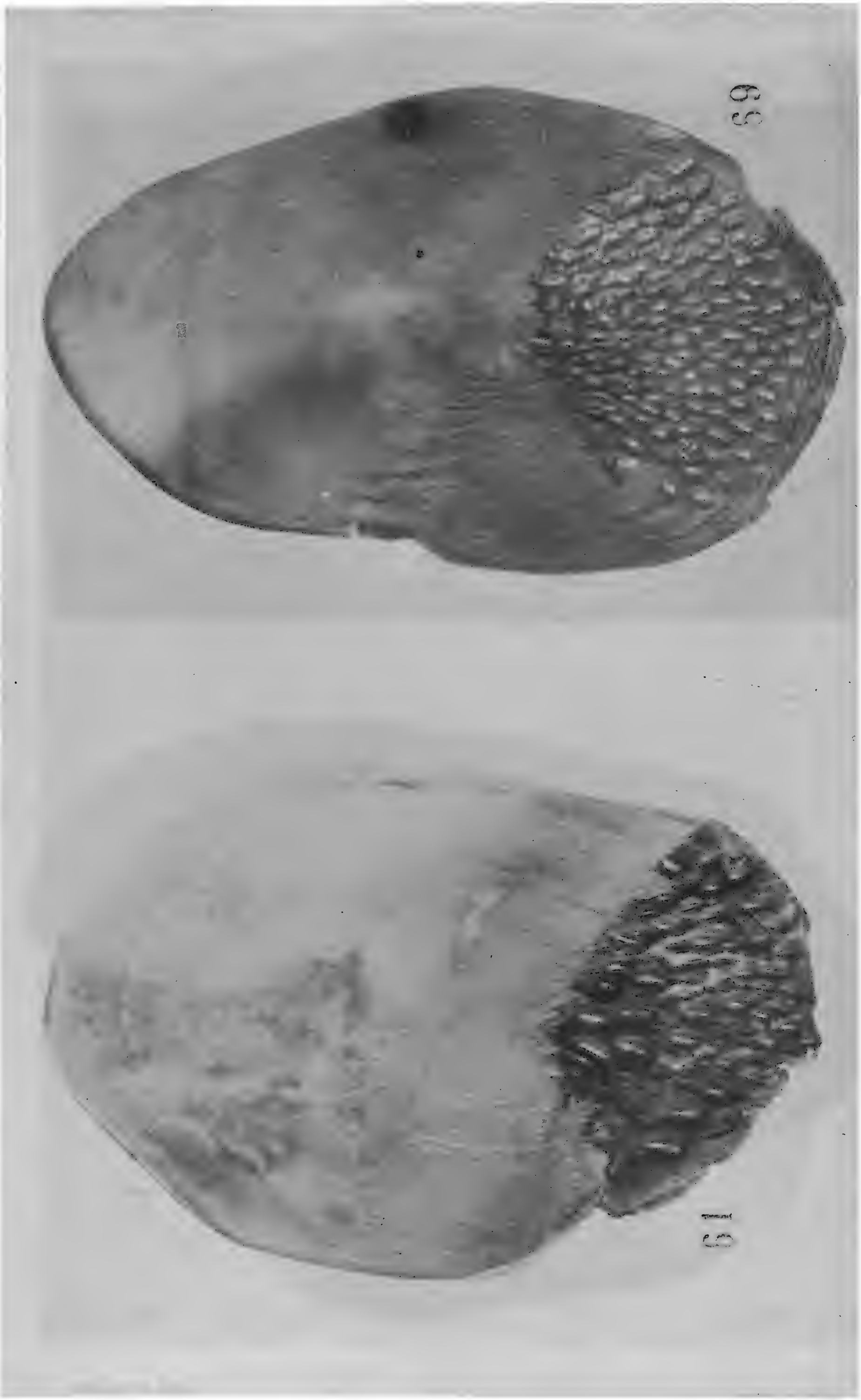


Latimeria chalumnae Smith.

74. Upper outer surface of pectoral peduncle, ×6·4.

77. Tubercle from scale on caudal peduncle below anterior rays, ×75.

See Folder-page II at end.



Latimeria chalumnae Smith.
61. Base of second dorsal (right side), × 2·2. 69. 4th row above lateral line, interdorsal, × 3·2.
See Folder-page II at end.

Latimeria chalumnae Smith. Ninth lateral line scale from left side, ×3.
Above: upper surface. *Below:* lower surface. Posterior margin of scale above.

J. L. B. Smith.

Neill & Co., Ltd.

Latimeria chalumnae Smith.
75. Anterior surface of anal peduncle, ×6·4. 67. 88th lateral line scale, ×10·2.
See Folder-page II at end.

Latimeria chalumnae Smith.
63. 18th lateral line scale, ×2·6. 64. 34th lateral line scale, ×2·6.
See Folder-page II at end.

J. L. B. Smith. *Neill & Co., Ltd.*

Latimeria chalumnae Smith.

76. Ventral anterior breast, ×2·5. 70. 4th row above lateral line, behind second dorsal, ×2·7.
See Folder-page II at end.

Latimeria chalumnae Smith.
73. 7th row below lateral line, behind pelvic base, ×2·3.
68. 5th row below lateral line, behind pectoral base, ×2·1.
See Folder-page II at end.

Transactions of the Royal Society of South Africa. Vol. XXVIII.
Part II. pp. 175–182. Pl. L. April, 1940.

SPARID FISHES FROM PORTUGUESE EAST AFRICA, WITH A NOTE ON THE GENUS *GYMNOCRANIUS* KLUNZINGER.

By J. L. B. Smith.

(With Plate L and three Text-figures.)

(Read September 20, 1939.)

A recent visit to Portuguese East Africa has revealed that area to be almost virgin ground to the ichthyologist. On practically every collecting trip there new species, or known species new to South Africa, were secured. In the markets appeared quite frequently large species hitherto unknown from Southern Africa, while some, rare even in Natal waters, proved to be exceedingly abundant there. Among others a new Sparid fish, described below, was obtained. The present work extends our knowledge of the distribution of Sparid fishes on the eastern coast of South Africa.

I wish to record my appreciation of the courtesy and cordial assistance received from the provincial and local authorities of Moçambique, and especially from the staff of the Alvarez da Castro Museum of Lourenço Marques.

Family Sparidae.

Argyrops spinifer (Forsk.).

Smith, Trans. Roy. Soc. S.A., 1938, vol. xxvi, p. 256.

This species is not infrequently encountered in Portuguese East African waters. Most specimens are half-grown, and are captured by lines at moderate depth.

Argyrops filamentosus (Valenciennes).

Smith, *ibid.*, p. 257.

It is remarkable that this Indian Ocean species was not known from our waters until 1935, when Fowler recorded a specimen from the Zululand coast. I now find it not uncommon on the coast of Portuguese East Africa, specimens 200–300 mm. in length being not infrequently taken by lines in 2–10 fathoms.

Examination of this recent material confirms my view that the species falls with *spinifer* (Forsk.) in *Argyrops* Swainson.

Pterogymnus laniarius (Cuv.).

Smith, *ibid.*, p. 258, fig. 12.

Very occasional specimens of this species are captured in Delagoa Bay. It is uncommon even in Natal, occurring chiefly farther south.

Chrysoblephus puniceus (G. & T.).

Smith, *ibid.*, p. 265, fig. 15.

This characteristic Natal fish is the most abundant large Sparid of Portuguese East Africa. It attains a much larger size than in Natal waters, specimens over 600 mm. in length being not uncommon, and as plentiful at Beira as off Delagoa Bay. In large adults the caudal lobes become more elongate, but the body shape does not alter much with growth. The characteristic line below the eye is constant in all stadia. The related *C. cristiceps* (Cuv.) was not found.

Chrysoblephus anglicus (G. & T.).

Smith, *ibid.*, p. 269, fig. 16.

This species, which is almost unknown south of Natal and is comparatively rare even in Natal waters, becomes more plentiful farther north and attains a large size. Specimens 800 mm. in length are not uncommon in Delagoa Bay and at Beira. The characteristic shape of the head does not alter with age.

Genus *Polyamblyodon* Norman.

Smith, *ibid.*, p. 288.

In his revision of the Sea Breams, Norman (Ann. S.A. Mus., 1935, vol. xxxii, p. 17) included *Pachymetopon gibbosum* Pellegrin in the synonomy of *Pachymetopon grande* Günther. In my revision of the Sparidae of South Africa (Trans. Roy. Soc. S.A., 1938, vol. xxvi, pp. 225–305) Norman's opinion was accepted, since Pellegrin's original description of *gibbosum* (Bull. Soc. Zool. France, 1914, vol. xxxix, p. 264) was then not available. A copy of that work has since been received. In view of Pellegrin's description (*loc. cit.*) Norman was rather venturesome in sinking *gibbosum* as a synonym of *grande* Günther, since it is clearly distinct. Norman's opinion caused Pellegrin to re-examine his single type (when he found, contrary to his original statement, that the preopercle flange was partly scaly) and to reassert (Bull. de l'Acad. Malg., 1935, vol. xviii, p. 145) the validity of *gibbosum*, which he placed in *Pachymetopon* Günther, grouping it with *aeneum* Gilchrist and Thompson, which species also has scales on the preopercle flange.

While collecting recently in Portuguese East Africa there was obtained a fish fairly common there related to the Sea Breams of South Africa, but clearly distinct from all the known species. Investigation revealed that it is strikingly similar to *gibbosum* Pellegrin, differing from the description of that species (and not very widely) in scale counts and in one or two other points. To make certain that those differences were valid, as I was unable to obtain Pellegrin's type for examination, I then wrote to Dr. Pellegrin giving

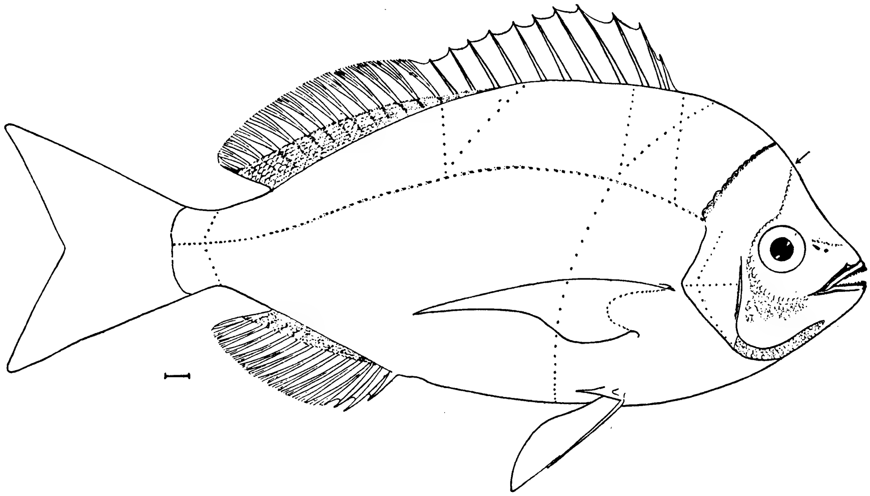


FIG. 1.—*Polyamblyodon cristiceps* sp. nov. (Type, 320 mm. length.)
The rows of dots show the number and disposition of the scale rows. The small arrow shows the anterior margin of the scaling on the head. The line represents 1 cm.

all details of my specimens, and requested him to re-examine his type with regard to them. His reply affirms the validity of his published description of *gibbosum*. Since the counts in my series of specimens are very uniform, I cannot but regard them as belonging to a new species, closely related to *gibbosum*, but distinguished from it as outlined below. *Gibbosum* and the new form, *cristiceps* sp. nov., are clearly congeneric and are generically distinct from all the known Sparid genera, save perhaps only the monotypic *Polyamblyodon* Norman, which is characterised (like *gibbosum* and *cristiceps*) by having a posterior band of molariform teeth in each jaw. The genotype, *Polyamblyodon germanus* (Barnard), has a fairly broad frontal region and naked preopercle flange, while the anterior incisors are large, chisel-like, and numerous. *P. gibbosum* and *cristiceps* have a sharp nape and some scales on the preopercle flange, while the incisors are rather small, lanceolate, and relatively few in number. If the latter two be accepted as congeneric with *germanus*, they form a definite subgroup within the genus. Their

close relationship, and the common difference from *germanus*, is as a compromise here given expression by subgeneric rank in *Polyamblyodon*.

The genus *Polyamblyodon* Norman may then be diagnosed as follows: Body ovate, compressed. Dorsal profile steep, and the supraoccipital elevated in the adult. Prefrontals well developed, forming a preorbital prominence. Preorbital fairly deep, the lower edge not notched. Posterior nostril slit-like. Cheek and opercular bones scaly, excepting preopercle flange, which is naked or partly scaly. Interorbital, snout, and chin naked. Dorsal with 11 moderate spines, not notched between spinous and soft portions. Soft dorsal and anal scaly on basal third of fin, no basal sheath. Scales feebly ctenoid. Lateral line tubes short, bifurcated posteriorly, with surface pores. Outer and anterior teeth incisiform, either chisel-like or lanceolate. An inner band of several rows of molariform teeth, either blunted or conical. Maxilla sometimes with an external roughened edge exposed beyond the lower preorbital margin. Gill-rakers lanceolate.

Key to the Species of Polyamblyodon.

I. (*Polyamblyodon*) Nape broad. Outer teeth strong, chisel-like, extend round jaws. Preopercle flange naked . . . . *germanus.*

II. (*Leptometopon*) Nape trenchant. Outer teeth rather slender, lanceolate, and present anteriorly only. A patch of scales on preopercle flange.

- A. Lateral line 63. 19 gill-rakers . . . . *gibbosus.*
- B. Lateral line 77–78. 16 gill-rakers . . . . . . *cristiceps.*

Subgenus *Leptometopon* nov.

Diagnosed in the key to the species (above).

Polyamblyodon (*Leptometopon*) *cristiceps* sp. nov.

Body oblong-ovate, fairly highly compressed, nape markedly cultrate. The dorsal profile of the head changes with age (text-fig. 2). In the young (260 mm.) the profile is moderately sloping, with a shallow gentle concavity above the anterior part of the eye. With age the profile becomes steeper and the concavity enlarges, until in a large adult the profile is almost sinuous, being strongly convex at the nuchal ridge, thence ventrally broadly concave to the somewhat simocephalous snout (text-fig. 2). The prefrontals are enlarged, forming a marked bulge on each side just anterior to the orbit and above the nostrils.

With age the lower jaw becomes increasingly more massive, until in large adults there is developed a strong "chin." Cheek and naked areas on head with large pores.

Depth 2·2–2·3, length of head 3·8–3·9 in length of body. Eye 3·6 (j.)–4·8 (ad.), snout 3·0–3·3, interorbital 2·6–3·1 (ad.), and postorbital part of

head 2·1 in length of head. Preopercle margin broadly concave, entire, angle enlarging somewhat with age. Outer edge of preopercle with radiate fine ridges. No opercular spine. Hind nostril slit-like or elongate-oval. Preorbital less than (1·3–1·2 in.) eye in juveniles, becomes deeper in adults, equal to eye. Pyloric caeca 4.

Mouth terminal, moderately protractile, maxilla extends to below the nostrils, not to eye. In juveniles the maxilla is largely concealed. The

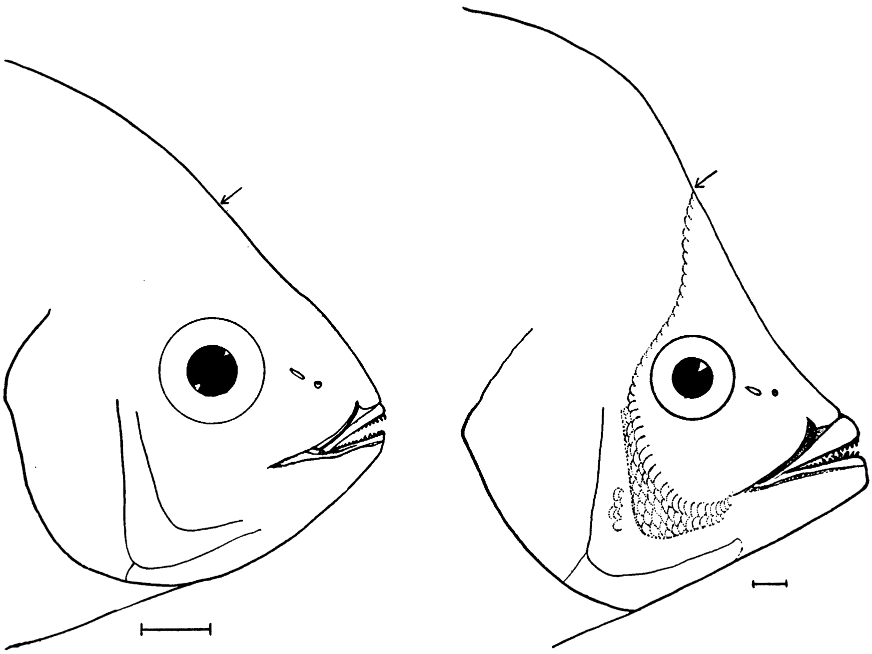


FIG. 2.—To show the change in shape of the head of *Polyamblyodon cristiceps* sp. nov. with growth. *Left*: of specimen 260 mm. in length. *Right*: specimen 510 mm. in length. Each line represents 1 cm. The small arrow shows the anterior margin of the scaling on the head. See fig. 1 for an intermediate stage.

maxilla has an external bony process along its anterior two-thirds, which is in the form of a downwardly projecting shelf. In juveniles the process is fairly small and thin, only the very sharp outer edge not being hidden below the lower preorbital margin when the mouth is closed. With age the process gradually increases and develops a thickened and rather rough outer lower margin, which is not covered by the preorbital. The anterior part of this ridge curls upwards round the anterior angle of the preorbital above the line of the upper jaw.

The dentition is in some respects close to that of *Gymnocrotaphus* Günther. In the front of each jaw is an external, almost exsert row of

moderate lanceolate incisiform teeth. Those in the lower jaw extend across the symphysis to half-way along the mandible, and are on each side discontinuous from an inner lateral row of similar but smaller teeth. The anterior teeth are lanceolate and but little compressed. With growth they change somewhat until in large adults the hinder teeth especially are almost conical and flare outwards. The inner lateral teeth are acutely triangular and incisiform. In the upper jaw there is also the outer anterior row and on each side an inner row, but there is not such an abrupt differentiation between them as in the lower jaw. The outer anterior teeth of the upper jaw are lanceolate and incisiform. In the upper jaw the outer series increases from 12 to 16, in the lower from 13 to 16 teeth with age. Inwards from, and behind, the outer series the inner posterior series increases from 12 to 15 incisiform sharp teeth on each side in each jaw, the anterior three being within the hinder of the front series. The total (outer) series of incisiform teeth increases from 30 to 40 in the upper, and from 31 to 40 in the lower jaw. In each jaw immediately behind the incisors are small molariform teeth in a band, broadest anteriorly, tapering postero-laterally. These teeth are somewhat irregularly arranged in irregular rows in each jaw. The number of rows increases from 3 to 5 or 6 with age. The teeth are so close set as to form almost a pavement across the symphysis. In juveniles these teeth are partly rather blunt, partly with sharp-pointed apices. With age the inner teeth appear to become more typically conical and pointed above. In a large adult practically all have sharp apices (text-fig. 3). Palate and tongue edentate.

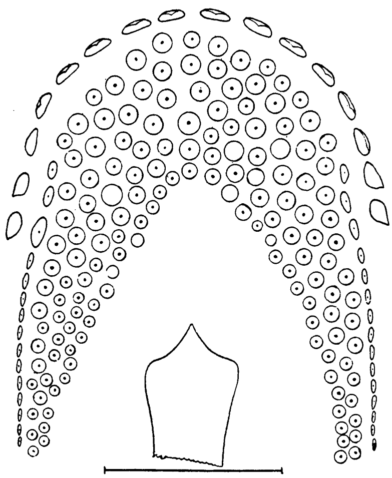


FIG. 3. — To show dentition in lower jaw of *Polyamblyodon cristiceps* sp. nov., semi-diagrammatic, from specimen 510 mm. in length. The line represents 1 cm. *Inset*, middle: a posterior molariform tooth. × 10 approx.

Sixteen gill-rakers on the lower limb of the anterior arch, of moderate size, 2·5 in gill-filaments, which are slightly greater than the eye diameter.

D XI, 13, first dorsal inserted just behind hind margin of opercle, scarcely notched between spinous and soft portions. Base of spinous dorsal 1·2 times, of soft dorsal 1·3 times head length. Spines moderate, fairly slender, membrane little incised. First spine 4·7, second 2·6–2·7, third 2·2–2·4, fourth and fifth subequal, longest 2·0–2·1 in length of head.

Remainder graduated shorter to the eleventh, which is 3·9–4·1 in head. First ray 3·0–3·1 in head, rays increase to third, 2·6 in head, thereafter subequal to the eleventh, last two shorter. Edge of soft fin gently and evenly convex.

A III, 10–11, inserted below the base of the fourth dorsal soft ray. First spine 4·6–4·8, second 3·2 in head, third equal or slightly longer. Soft rays about equal to the last spine, edge of fin gently and evenly convex. Base of anal 1·3 in head. Pectoral falcate, 1·35 times head, reaches to above anal origin. Ventrals 1·35 in head, inserted behind pectorals, below the base of the third or fourth dorsal spine. Axillary scale about one-third the length of the fin. Caudal moderately forked. Peduncle fairly slender, least depth 4·0–4·1 in depth of body.

Scales ctenoid, moderately small. Circuli fine, radiating striae fairly numerous. Exposed area of scale largely covered by adjacent radiating series of rather broad overlapping spinelets, forming a rough surface of characteristic appearance (see Plate L). Scales below the lateral line rather larger than those above. Lateral line scales of moderate size, tubes fairly wide, bifurcated posteriorly, with a series of pores along the line of each diverging tubule. In Plate L the chromatophores in the skin covering the scales are clearly visible.

L.l. 77–78, l.tr. $\frac{11\text{–}12}{22\text{–}24}$, 5–6 series on cheek. Scaling on nape extends to above centre of eye. Front part of head, *i.e.* interorbital, supraorbital, snout, most of cheek, and chin, naked. Preopercle flange mostly naked, but a small patch of scales in the middle of the wide flange near the angle (one small specimen shows no sign of scales on the preopercle flange). A row of heavy dark scales from suprascapula to occiput. Soft dorsal and anal densely scaly at base, deeper posteriorly. Pectoral base and most of caudal scaly.

Colour.—Uniform grey-blue to dusky above, shading to light below. Iris bronzy. Tips of ventrals, pectoral axil, and caudal lobes dark. Fins otherwise generally light.

Length.—Up to 560 mm.

Locality.—Delagoa Bay up to 20 fathoms, generally taken on lines.

Type.—An adult female, 320 mm. in length, in the Albany Museum.

This species is distinguished from *gibbosus* Pellegrin by the following characters:—

	gibbosus.	*cristiceps.*
Scales, lateral line	63	77–78
Scales, l.tr.	8/18	11/22
Gill-rakers	19	16
Length of pectoral, times head	1·5	1·35
Dorsal formula	XI, 12	XI, 13
Outer incisors	27/24	12–15/12–15

P. cristiceps is not a very plentiful species in Mozambique waters, nor has it any well-known common name. It is not very highly esteemed as a table fish.

Of seven specimens examined, all were females, none fully ripe (August).

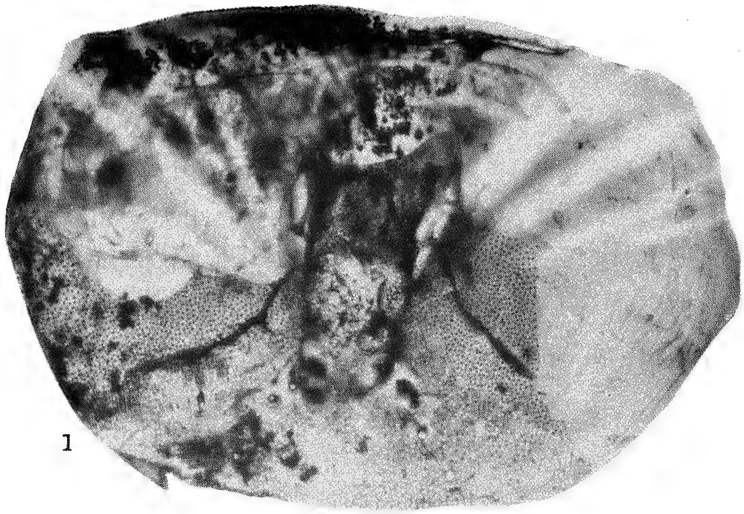
Genus *Gymnocranius* Klunzinger.

In a revision of the Sparid and Denticid fishes of South Africa (Smith, Trans. Roy. Soc. S.A., 1938, vol. xxvi, p. 225) previous workers were followed in accepting *Gymnocranius* as a Denticid genus, since superficially it appears to belong there, and the only specimens available to me were loaned, and not for dissection. Preliminary superficial dissection of material recently obtained in Portuguese East Africa has shown that by the nature of the maxillary bones *Gymnocranius* cannot belong either to the SPARIDAE or to the DENTICIDAE. In so far as my present examination has proceeded, *Gymnocranius* appears almost certainly to fall in the LUTIANIDAE, but a special study of the genus is in progress.

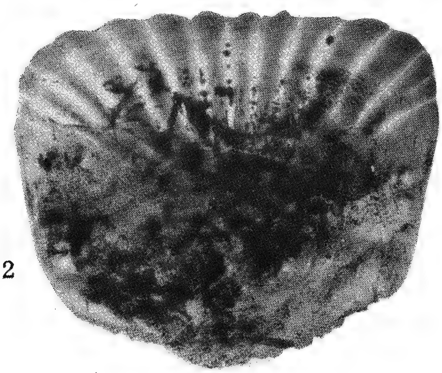
Hitherto only the species *Gymnocranius robinsoni* (Gilchrist and Thompson) has been recorded from the South African region. *G. griseus* (Schlegel) has now been found to be fairly abundant in Delagoa Bay. This species has been recorded from Mauritius to Japan.

I wish to express my gratitude to the National Research Board for financial assistance.

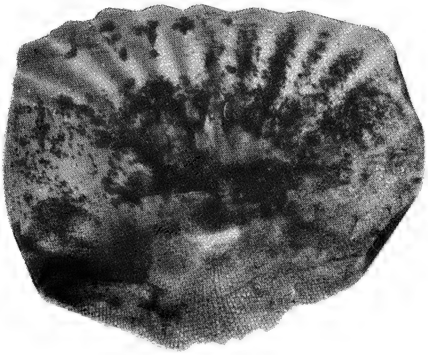
ALBANY MUSEUM,
GRAHAMSTOWN,
2nd September 1939.



1



2



3

Polyamblyodon cristiceps sp. nov. Scales.

1. 11th lateral line scale. × 12.
2. The 7th scale ventral from the 11th lateral line scale. × 5·5.
3. The 4th scale dorsal from the 11th lateral line scale. × 8.

The posterior margin of each scale below.

J. L. B. Smith. *Neill & Co., Ltd.*

Transactions of the Royal Society of South Africa. Vol. XXVIII.
Part V. pp. 441–452. Pl. LVIII. November, 1941.

THE GENUS *GYMNOCRANIUS* KLUNZINGER, WITH NOTES ON CERTAIN RARE FISHES FROM PORTUGUESE EAST AFRICA.

By J. L. B. Smith.

(With Plate LVIII and one Text-figure.)

(Read August 21, 1940.)

During a revision of the South African Sparidae and Denticidae, I was able to examine two specimens of "*Dentex robinsoni*" Gilchrist and Thompson, on loan from the South African Museum. It was immediately obvious that the specimens were not congeneric with any other Denticid fishes in South Africa, and the species was placed in *Gymnocranius* Klunzinger. Since those borrowed specimens were not available for dissection, Barnard's diagnosis that they fell in the DENTICIDAE (i.e. *Dentex* Cuvier in the SPARIDAE *fide* Barnard) was provisionally accepted. Barnard had identified the specimens as *rivulatus* Rüppell, but since that name had been preoccupied (Bennett, 1835), a later synonym, *robinsoni* Gilchrist and Thompson, was accepted as valid.

During a recent visit to Portuguese East Africa a graduated series of specimens of "*Gymnocranius robinsoni*" was obtained, and a detailed study of those has led to an investigation extending far afield. In so far as the identity of the species is concerned, our specimens have erroneously been identified with *rivulatus* Rüppell, and are without question conspecific with the Indo-Pacific *griseus* Schlegel. Thus, since *robinsoni* Gilchrist and Thompson is shown to be a synonym of *griseus* Schlegel, and *rivulatus* Rüppell is invalid, it becomes necessary to rename that species, and *ruppellii* nom. nov. is now proposed.

Among the Perciformes there is a characteristic group of families which may be termed the Spariform fishes. These are characterised by the following: always 24 (10+14) vertebrae; emarginate, usually forked, caudal; moderate to small mouth, moderately protractile, with well-developed dentition; single dorsal with fairly strong spines, the spinous portion as a rule longer than the soft; the opercular bones not strongly spinate. These fishes are mostly littoral, few extending to deeper water, and they are found chiefly in the tropics, mostly in the Indo-Pacific. The families in this group are the SPARIDAE, the DENTICIDAE, the LUTIANIDAE, the LETHRINIDAE, and the NEMIPTERIDAE.

*

Dissection has shown that while *Gymnocranius* is undoubtedly Spariform (as here defined), and shows affinities with all the families, it cannot be placed in any of them, since it differs from any one by features of significance as great as those held to differentiate the existing families one from the other. Thus *Gymnocranius* cannot be placed in the SPARIDAE, DENTICIDAE, or NEMIPTERIDAE because of the structure of the maxillary bones, and of the reduced subocular shelf; nor in the LUTIANIDAE because of the nature of the subocular shelf, and because of the absence of palatal teeth, and of a supra-premaxillary process. From the LETHRINIDAE *Gymnocranius* differs in the nature of the subocular shelf, as well as in the structure of the maxillary bones, in the absence of transverse processes from the first two vertebrae, and by the scaling on the head.

A search for the nearest allies of *Gymnocranius* has revealed that several Spariform genera are indeed more closely related to *Gymnocranius* than to any genera in the families in which they have usually somewhat anomalously been placed, and that those genera with *Gymnocranius* form a structurally related group clearly differentiated from all other families of Spariform fishes.

The genera *Gnathodentex* Bleeker and *Pentapodus* Quoy and Gaimard certainly fall with *Gymnocranius*, and *Monotaxis* Bennett is also very closely related. These four genera contain small or moderate-sized carnivorous fishes, of similar habits and habitat, from the tropical Indo-Pacific. It is proposed that these receive distinction in the Spariformes by full family rank. Since *Pentapodus* Quoy and Gaimard is the oldest genus, the family is designated the PENTAPODIDAE.

It is immediately admitted that this diagnosis is venturesome in that I have been able to examine only one species of *Gymnocranius* and one of *Gnathodentex*, and that literature at my disposal is scanty. At the same time I have little hesitation in presenting the conclusions here set forth, since exhaustive analysis has pointed very clearly to them.

The taxonomic relationships of the families of the Spariformes and the clear distinction of the PENTAPODIDAE is shown by the following Key:—

Key to the families of the SPARIFORMES.

1. Subocular shelf strong, covering at least one-third of the subocular floor.
   - A. Premaxilla distally overlaps the lower edge of the maxilla. No superior process on ramus of premaxilla internal to the maxilla.
     - *x*. Molars and/or incisiform teeth present . . . SPARIDAE.
     - *y*. Neither molars nor incisiform teeth present . . DENTICIDAE.

B. Premaxilla distally slips beneath maxilla. A superior process on premaxillary ramus which is internal to the maxilla.
x. Palate edentate . . . . NEMIPTERIDAE.
y. Some teeth on palate * . . . . . . LUTIANIDAE.
2. Subocular shelf feeble, at most a small triangular antrorse expansion from the second suborbital.
A. Cheeks naked. Subocular shelf vestigial . . . . LETHRINIDAE.
B. Cheeks scaly. Subocular shelf a triangular antrorse projection from the second suborbital . . . . PENTAPODIDAE.

FAMILY PENTAPODIDAE nov.

Body oblong-oval, fairly compressed. Head fairly broad, interorbital convex, prominent, prefrontals enlarge and form a preorbital prominence with age. Eye large. Nostrils both more or less circular.

Gill-rakers few, short, tubercular. Gill-membranes at most narrowly united, free from isthmus. Pyloric caeca few. Air-bladder notched posteriorly, with caudal horns. Dorsal spines 10, moderate, rays few. 3 anal spines. Caudal forked.

Mouth moderate or small, moderately protractile. Premaxillary rami shorter than pedicels, extremity internal to the maxilla, but without supero-posterior process behind the maxilla. Maxilla with broad posterior expansion. Anterior teeth conical, usually multiserial anteriorly, with a few antero-exterior enlarged, caniniform teeth. Laterally a single series of conical or molariform teeth. Palate and tongue edentate.

Subocular shelf small, in the form of a flat antrorse triangular projection from the upper anterior edge of the second suborbital, projecting within the first. Parietal and occipital crests well developed. Vertebrae 24 (10 + 14). Either all the vertebrae with parapophyses (*Gnathodentex*) or parapophyses from the third (*Gymnocranius*). The first rib sessile.

Scales moderate or large, feebly (to moderately) ctenoid. Head partly scaly. Interorbital naked or scaly. Cheeks scaly. Preopercle flange naked or scaly. Interopercle scaly only posteriorly. Dorsal and anal naked with low sheath, or with very low basal scaling posteriorly.

Key to the Genera.

1. Lateral teeth conical, sharp.
Snout conical or at most moderately steep.
A. All canines normal . . . . *Gymnocranius.*
B. Lower canines flare outward.
x. Outer surface of maxilla smooth . . . . . . *Pentapodus.*
y. Maxilla with external denticulate ridge . . . . *Gnathodentex.*
2. Lateral teeth molariform. Snout very steep and abrupt . . . *Monotaxis.*

* *Aphareus* Cuv. is generally placed in the LUTIANIDAE. Since it has an edentate palate and (11 + 13) vertebrae, investigation may show that it falls elsewhere.

**

Of the genera included, *Gymnocranius* Klunzinger has usually not been accepted as valid. Neither Regan (Ann. Mag. Nat. Hist. (8), vol. xii, 1913, pp. 111–145) nor Barnard (Ann. S.A. Mus., vol. xxi, 1927, p. 712) considered *Gymnocranius* worthy of consideration at full rank. Barnard placed the species in *Dentex* Cuvier, a diagnosis which has earlier been shown to be invalid (Smith, Trans. Roy. Soc. S.A., vol. xxvi, 1938, p. 291). Fowler (U.S. Nat. Mus. Bull., 100, vol. 12, 1933, p. 129) assigned *Gymnocranius* full rank in the SPARIDAE, but in his Key to Sparid genera characteristically defined *Gymnocranius* by an invalid feature. (See Smith, Trans. Roy. Soc. S.A., 1938, vol. xxvi, p. 227.)

Gnathodentex Bleeker has not been accepted by Fowler (*ibid.*, p. 69), who regarded it as a synonym of *Pentapodus* Quoy and Gaimard, but the genus appears worthy of maintenance, and is here accepted at full rank.

Genus GYMNOCRANIUS Klunzinger.

Smith, Trans. Roy. Soc. S.A., vol. xxvi, 1938, p. 291.

Body ovate, compressed. Eye large. Snout conical in juveniles, becomes steeper with age, with enlargement of the prefrontals.

Dorsal with 10 spines and 10–11 rays. A III, 9–10. All spines moderate. No fins greatly filamentous, first ventral ray sometimes extended. Caudal forked to lunate.

Scales feebly ctenoid, about 50 series. Cheeks with 4–5 series of scales. Interorbital and preopercle flange naked. Interopercle naked anteriorly. A naked groove in the scaling on each side of nape. Dorsal and anal with low basal scaling posteriorly.

Mouth small or moderate, jaws subequal. Villiform teeth in a band anteriorly in each jaw. A few antero-exterior enlarged teeth, normally caniniform. A single lateral row of sharp conical teeth. Premaxillary rami much shorter than pedicels, extremities slip beneath the maxilla.

Subocular shelf small, triangular, antrorse, from the anterior margin of the second suborbital, and internal to the first. Precaudal vertebrae with parapophyses from the third, the first rib sessile, but inserted behind the process so that it proximally lies against its posterior face.

Tropical Indo-Pacific fishes of moderate size, silvery to rose in colour in life. Generally six species have been accepted, though in 1933 Fowler (*loc. cit.*, p. 130) reduced the number to five, admitting *griseus* Schlegel, *microdon* Bleeker, *frenatus* Bleeker, *bitorquatus* Cockerell, and *robinsoni* Gilchrist and Thompson. I have seen only South African specimens from Natal and Portuguese East Africa, and they are all unquestionably referable to *griseus* Schlegel. Fortunately a regular series of graduated growth stadia has been secured, which shows clearly that this is a variable species,

and that changes occur with growth, chiefly in the form of the dorsal profile of the head. From the descriptions of *microdon* Bleeker available to me, my material shows that species almost certainly to be identical with *griseus* Schlegel. Also, one of my specimens which might well be identified as *frenatus* Bleeker is unquestionably conspecific with the remainder. Therefore, only three species in this genus, i.e. *griseus* Schlegel, *bitorquatus* Cockerell, and *ruppellii* nom. nov., are admitted here, and it would not be surprising if *ruppellii* eventually proves to be merely a colour variety of *griseus*: they differ in nothing else of significance. Between these three species admitted indeed the only feature of any significant differentiation is the coloration. At the same time, the three are in some degree expressions of geographical distribution, *griseus*, however, occurring throughout almost the whole Indo-Pacific.

Key to the species of Gymnocranius.

1. Wavy blue lines on snout and cheeks . . . . *ruppellii.*
2. No wavy blue lines on head.
   A. Preorbital deeper than eye. A white loop in shoulder . . . *bitorquatus.*
   B. Preorbital not deeper than eye. Dark cross-bars; a bar through eye on cheek; a dark mark above pupil variably present . . *griseus.*

Of the above, *bitorquatus* is known only from Australia, and is distinguished by a fairly deep preorbital, and by the white collar over the nape.

Gymnocranius griseus (Schlegel).

Gymnocranius griseus (Schlegel). Fowler, U.S. Nat. Mus. Bull., 100, 1933, vol. 12, p. 130.

Gymnocranius robinsoni (G. & T.). Smith, Trans. Roy. Soc. S.A., 1938, vol. xxvi, p. 291; Fowler, *loc. cit.*, p. 133 (part).

Dentex robinsoni Gilchrist and Thompson. Gilchrist and Thompson, Ann. S.A. Mus., vol. vi, p. 228, 1908; Barnard, Ann. S.A. Mus., vol. xxi, p. 712, 1927 (Natal).

Dentex rivulatus Ruppell. Gilchrist and Thompson, Ann. Durban Mus., vol. i, 1917, p. 356 (Natal).

Gymnocranius microdon (Bleeker). Fowler, *loc. cit.*, p. 132.

Gymnocranius frenatus (Bleeker). Fowler, *loc. cit.*, p. 133.

Body ovate, fairly compressed. Dorsal profile sloping gently in juveniles, with a slight supraorbital depression. With growth the profile becomes more abrupt, with the development of an antorbital prominence. The snout is subconical in juveniles and early adult stadia, more abrupt in adults. The nape is fairly sharp in juveniles, broadens somewhat with growth.

None of the opercular bones serrate, a moderate flat spine on opercle. The interorbital is only partly bony, the frontals being deeply concave above the eyes.

Depth 2·4–2·5, length of head 2·9–3·2 in length of body. Eye 2·9–3·1, snout 2·6–3·0, postorbital part of head 2·9–3·1, interorbital (total) 2·9–3·0, interorbital (bony) 3·5–3·6 in length of head. Lower margin of preorbital gently undulate, depth 1·4–1·7 in eye. Naked parts of head, *i.e.* snout, preorbital and interorbital, much pitted, spongy. Preopercle margin almost straight, broadly rounded at angle, outer margin with radiate fine ridges. Hind nostril circular. Pyloric caeca 2, one short, robust, the other longer, characteristically folded over the smaller.

On lower limb of anterior arch 5–6 gill-rakers, rudimentary spinate knobs. Gill membranes not united, free from isthmus.

Mouth terminal, moderate, very slightly oblique and only moderately protractile. Maxilla extends to below nostrils, almost below anterior margin of eye. The maxilla for the greatest part slips beneath the preorbital, but is distally exposed. With age the lips thicken considerably. In the lower jaw there is a patch of sharp curved villiform teeth closely adjacent on each side of the symphysis. Antero-exteriorly are usually 6 small to moderate canines, variable in size, position, and form, though the outer are generally the largest. Laterally, along the mandible, are on each side 6–9 fairly robust conical teeth in a single series. In the upper jaw the villiform teeth are in a band which is widest anteriorly, and which extends farther along the inner margin of the jaw, almost to the distal end of the pre-maxilla. There are usually 6 antero-exterior subequal caniniform teeth. Behind these, along the margin of the jaw, are on each side 5–7 fairly robust conical teeth. Palate and tongue edentate (text-fig. 1). Premaxillary pedicels 1·7 times rami.

D X, 9–10, inserted above behind hind margin of opercle. Base of spinous portion 3·3–3·4, of soft portion 4·9–5·2 in length of body. 1st spine 4·4–4·7, 2nd and 6th 3·0, 3rd 2·4–2·7, 4th 2·2–2·3 in head, remainder graduated shorter to the subequal 8th and 9th, 3·8–4·0 in head. Soft rays higher than last spine, 5th–7th longest, about 2·3 in head. Edge of soft fin gently and evenly convex. Pectorals 1·25–1·33 in head. Ventrals with first ray extended, 1·1–1·4 in head, reach to vent. Caudal almost lunate in juveniles, becomes less deeply incised in adults. Peduncle fairly slender.

Scales large, only feebly ctenoid. L.l. 47–50, l.tr. $\frac{6\text{–}7}{16\text{–}18}$, 4–5 series (usually 5) on cheek. 10–11 oblique rows predorsal. Lateral line tubes moderate, slightly oblique, without posterior pores. Predorsal scales

extend to above the hind margin of the orbit, sometimes a little farther forward in juveniles, but the interorbital is always naked. Preopercle flange naked. Only the hinder portion of the interopercle is scaly. Snout and chin naked. Hind portion of soft dorsal and anal scaly basally only.

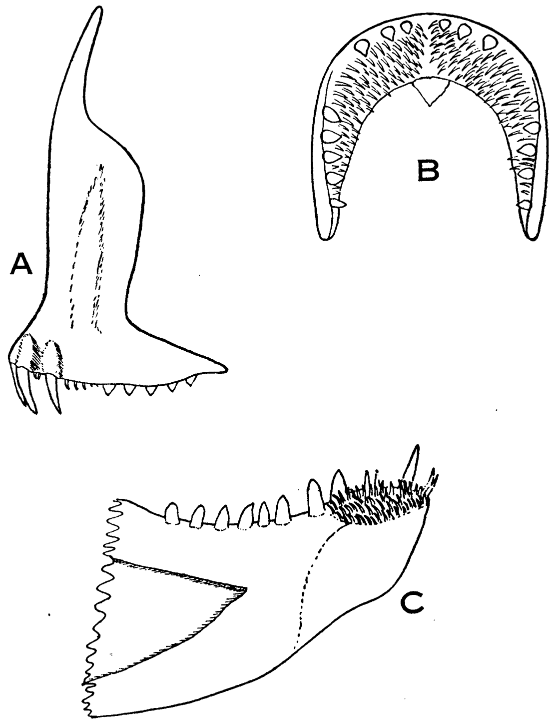


FIG. 1.—*Gymnocranius griseus* (Schlegel).

A. Side view of premaxilla. B. View of upper jaw from below. C. Dentary from within. Villiform teeth not accurately to size or number. All × 2. From specimen 255 mm. in length.

Colour.—Juveniles, alive. Specimens up to about 180 mm. in length are silvery, slightly darker above, with few definite markings. As death approaches, 6–10 somewhat oblique narrow dark cross-bars, and numerous black spots, flash up spasmodically, and fade more slowly. The dark spots are more numerous on the caudal region. After death the dark markings slowly fade, most of the spots vanishing completely, while the cross-bars are of much diminished intensity.

Juveniles, preserved. The body is silvery-olive, lighter below. There are 8–10 narrow dusky cross-bars, the 1st from the interorbital through the eye across the cheek to the interopercle. The 2nd from the occiput

behind the orbit, in some cases continued to the chest. The 3rd runs from the nape, through the pectoral base, to the ventral origin, broadening, but becoming fainter below. The 4th runs backwards and downwards from the origin of the spinous dorsal, and fades below the lateral line. The 5th originates below the 5th–6th dorsal spines, and runs backwards and downwards, becoming fainter but fairly wide near the flank. The 6th originates with the soft dorsal, and runs backwards and downwards to the lateral line, where it turns gently forward and runs to the base of the anal spines: at each end it spreads over the membranes of the fins. The 7th is usually short and faint, originating below the last dorsal rays, and running forwards and downwards, fading out just below the lateral line. The 8th comes over the peduncle, and runs forwards and downwards to the middle of the anal. There are usually one or two variable bars or blotches on the hind part of the peduncle. There are 3–5 faint cross-bars on the caudal, medially very faint, appearing in some specimens merely as blotches along each lobe. All the main cross-bars are continuous dorsally, those on the nape markedly so. In some specimens there appears to be a dusky bar over the snout to the chin. Occasional dark spots, chiefly on the peduncle and caudal base.

Dusky scale centres form longitudinal lines of the scale rows, most noticeable on the flanks. Iris yellow-bronze. Membrane of spinous dorsal and anal dusky. Ventrals distally dusky. Caudal dusky. Pectoral, soft dorsal, and anal, light. Breast noticeably light.

Adults, preserved. Light olive or very light brown, lighter below. Markings are usually faint, but some or all of the bars described in the juveniles can quite clearly be traced. The bar across the cheek, with a dark blotch on the iris above, and the peduncular bar sloped forward and downward, are found in most specimens.

Length.—Up to 400 mm.

Locality.—Natal; Portuguese East Africa.

Distribution.—Indo-Pacific.

It is a peculiarity of this species that the eye remains of almost constant relative size, or even appears to increase slightly with age in some specimens. It is possible that this may be a result of environment, for while juveniles are commonly found in shallow water, adults are usually taken on lines in deeper water, though not at great depths where enlargement of the eye is commonly found.

Although rare in Natal waters, *griseus* is not at all uncommon farther north. At Lourenço Marques and Beira, specimens are usually to be found among the catches of the line-boats. In Delagoa Bay, about Inhaca Island, juveniles are frequently caught in fair numbers by nets. The species is conspicuous in the catch by the manner in which black cross-bars

and spots periodically blaze up and fade away on the silvery fishes. The fishermen had no particular name for this species.

This species appears to feed chiefly upon crustacea.

Gymnocranius ruppellii nom. nov.

Dentex rivulatus Rüppell (*non* Bennett). Rüppell, Neue Wirbelth. Fische, p. 116, pl. 29, fig. 2, 1835; Day, Fishes of India, 1875, p. 90.

Gymnocranius robinsoni (Gilchrist and Thompson). Fowler, U.S. Nat. Mus. Bull., 100, 1933, vol. 12, p. 133.

The species has been recorded from the Red Sea and from Ceylon. Fowler (*loc. cit.*, p. 134) includes a record by Pellegrin (Bull. Soc. Zool. France, vol. xxxix, p. 229, 1914) from Madagascar. I have not seen this record or description, so do not include it above.

There is little to distinguish this species from *griseus* Schlegel, save the blue markings on the head, and a doubtfully deeper preorbital. It has not yet been found in our region, though, if Pellegrin's record is valid, it doubtless occurs in the waters of Portuguese East Africa.

Genus GNATHODENTEX Bleeker.

In all respects similar to *Gymnocranius* excepting: a shallower preorbital; a serrated external bony ridge on the maxilla; the lower outer canines flaring outwards; and the soft dorsal and anal entirely naked with low sheath. Brief examination shows how clearly *Gymnocranius* and *Gnathodentex* are related, and there is no doubt that they fall in the same family.

The genus is monotypic. The single Indo-Pacific species *aurolineatus* Lacepede was first recorded from South Africa (Delagoa Bay) in 1939 (Smith, Trans. Roy. Soc. S.A., 1939, vol. xxvii, p. 218).

Genus PENTAPODUS Quoy and Gaimard.

Fowler, U.S. Nat. Mus. Bull., 100, 1933, vol. 12, p. 69.

Pentapodus differs from *Gnathodentex* Bleeker chiefly in the absence of the serrated maxillary ridge. A number of species from the Indo-Pacific have been described, and though I have seen no specimens, the general characters of the genus and the species leave no doubt that they fall with *Gymnocranius*. It appears likely that critical revision will divide the genus *Pentapodus* Quoy and Gaimard, as at present accepted, into at least two genera. This cannot be attempted without actual specimens, not at present available.

Genus Monotaxis Bennett.

Fowler, U.S. Nat. Mus. Bull., 100, 1933, vol. 12, p. 134.

This genus is closely related to *Gymnocranius* Klunzinger by the following characters in common: dorsal and anal fin formulae; few, knob-like gill-rakers; anterior dentition; fairly large scales, less than 50 series; naked interorbital and preopercle flange; few cheek scales; large eye; few pyloric caeca.

In the PENTAPODIDAE *Monotaxis* is clearly distinguished from all other genera by the lateral molar teeth, uniserial in each jaw, as well as by the very abrupt convex profile of the snout.

The single species *grandoculis* Forskäl appears to be distributed throughout almost the whole of the tropical Indo-Pacific, and to occur abundantly at many places. It has been recorded from Madagascar. I could find no indication that the species had been seen in Portuguese East Africa, though I have little doubt that it should occur there.

Family NEMIPTERIDAE.

Nemipterus delagoae nom. nov.

Nemipterus mulloides Smith, Trans. Roy. Soc. S.A., 1939, vol. xxvii, p. 129, fig. 2.

The new name is necessary since *mulloides* is invalid, having been preoccupied by *mulloides* Bleeker (1852).

Family SERRANIDAE.

Variola louti (Forskäl).

Day, Fishes of India, 1875, p. 26, pl. vii, fig. 3.

This handsome and unmistakable Serranid has been found to be an occasional capture in the waters off Delagoa Bay. Specimens up to 800 mm. in length were observed.

This species has not previously been recorded from South Africa, although reported from Zanzibar in 1866 (Playfair).

Family PLATACIDAE.

Tripterodon orbis Playfair.

Smith, Trans. Roy. Soc. S.A., 1935, vol. xxii, part iv, pp. 303–310.

This little-known species was first described in detail in the above paper. Even at that time comparatively few specimens were available, and the species was stated (p. 310) to be everywhere apparently rather scarce. The largest recorded size (Playfair) was 300 mm. It has subse-

quently been found that *T. orbis* occurs abundantly in the reefs in and about Delagoa Bay and on the coast of Portuguese East Africa. In certain localities the young are frequently taken in number by nets, while the adults are taken by lines from boats. The species attains the surprising size of over 20 lbs. in weight and 500 mm. in length. In these large, not uncommon, specimens the body is somewhat less deep and less orbicular than in the juveniles, while the 3rd to 5th dorsal spines are less elongate. Otherwise there is little change with growth.

Family SCORPAENIDAE.

Amblyapistus binotota (Peters).

Amblyapistus marleyi Regan. Regan, Ann. Durb. Mus., 1919, vol. ii, part iv, p. 202, fig. 5; Barnard, Ann. S.A. Mus., 1927, vol. xxi, p. 917; Smith, Rec. Alb. Mus., 1931, vol. iv, part i, p. 156.

Barnard (*loc. cit.*, p. 918) called attention to the similarity between *binotota* Peters and *marleyi* Regan, but was not able to proceed farther in the absence of specimens. *Binotota* has been regarded as distinct from *marleyi* solely because the former was stated to have a round white spot on each side (hidden beneath the pectoral). *Binotota* is by no means uncommon in shallow water in and about Delagoa Bay, and the live fishes all have the white spot on the side, which, however, vanishes on preservation, when the specimens are indistinguishable from "*marleyi*."

The native fishermen would not handle this species, and stated that its spines inflict painful wounds.

Family SYNANCIIDAE.

Synanceia verrucosa Bl. Schn.

Day, Fishes of India, 1878, p. 162, pl. xxxix, fig. 4.

This species was recorded from Zanzibar (without description) by Playfair (Fishes of Zanzibar, 1866, p. 49). Barnard (Ann. S.A. Mus., 1927, vol. xxi, p. 920) predicted that *S. horrida* (Linn.) would be discovered in our region. Recently it has been found that one species of *Synanceia* Bl. Schn. occurs in and about Delagoa Bay, thus probably throughout the waters of Portuguese East Africa.

According to Day's diagnoses (above) *verrucosa* and *horrida* are well differentiated from one another. The South African specimens agree closely in all respects with *verrucosa* Bl. Schn. as defined by Day. A single specimen from Delagoa Bay is described briefly below.

Head depressed, no saddle-shaped depression behind orbits, but a deep interorbital pit about as wide as eye. Body and fins with numerous

tuberculate excrescences. Gill-rakers merely low rudimentary spinate excrescences, 7 or 8 on the lower limb of the anterior arch. Apparently no slit behind the last gill. Two slender pyloric caeca. Stomach very thick and muscular. Teeth villiform, palate and tongue edentate.

D XIII, 7, the first three spines not markedly separate from the remainder, only the 2nd spine slightly higher than the 4th. A III, 5. P 19. Inner margin of ventrals adnate to body. Caudal rounded.

Colour dark brown, almost black, with an indefinite lighter wide cross-bar from over the middle of the spinous dorsal, another, fainter, from the soft dorsal. Extremities of spines and rays of dorsal, anal, pectoral and ventral light. Caudal light with a wide dark bar across the middle.

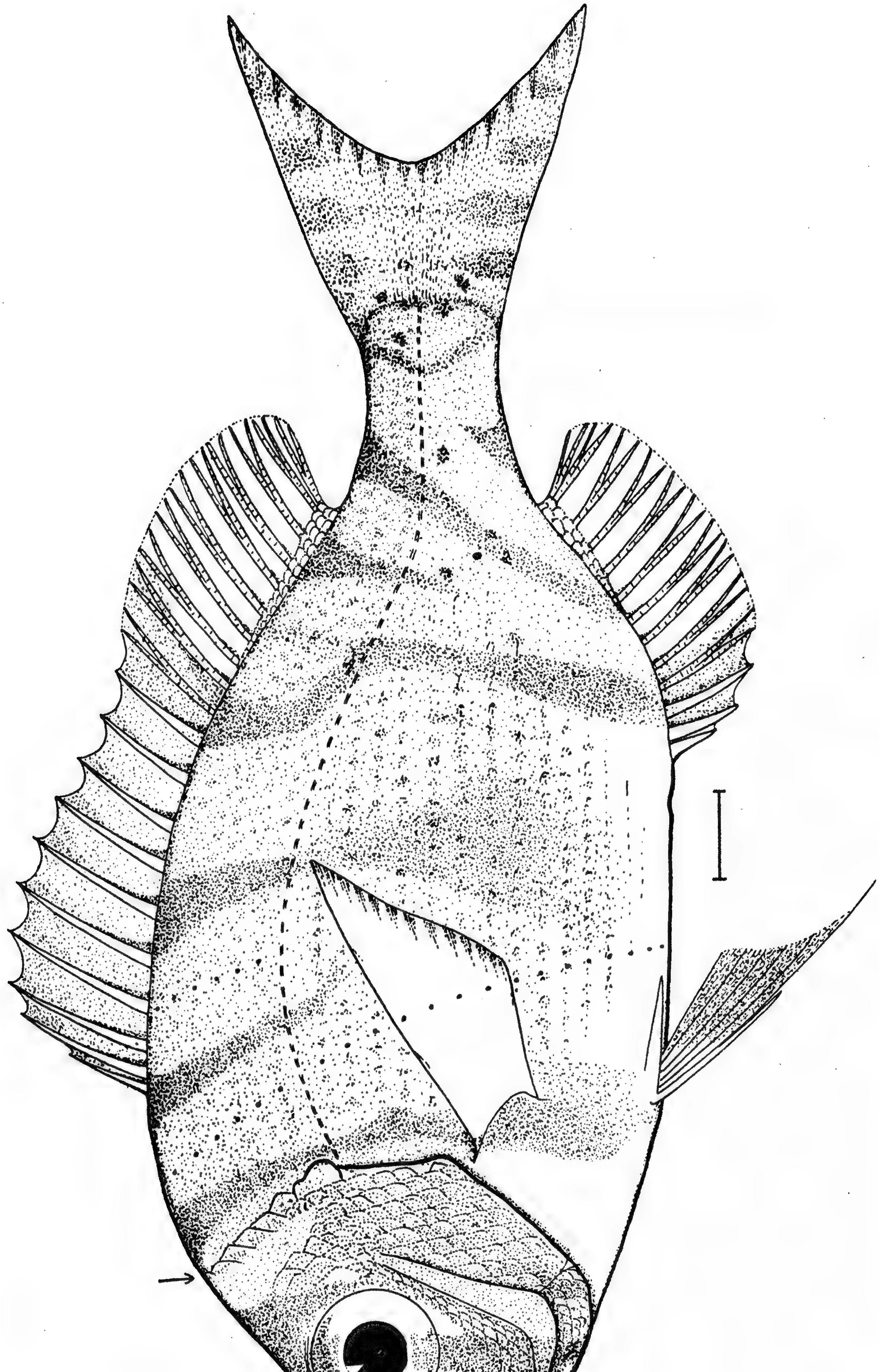
The specimen is an immature male, 130 mm. total length.

It is possible that *horrida* and *verrucosa* are sexual dimorphs, but material is not available to settle this point.

S. verrucosa occurs from the East Coast of Africa through the Indian Ocean (Day) to the Eastern Pacific (Fowler, Fish. Geo. Vand. S. Pac. Exp., 1938, p. 174).

I wish to express my gratitude to the National Research Board of South Africa for financial assistance which has defrayed part of the cost of the investigation.

ALBANY MUSEUM,
GRAHAMSTOWN,
July 1940.



Gymnocranius griseus (Schlegel). Juvenile.

The line represents 1 cm. The rows of large dots across the body represent scale rows.

J. L. B. Smith. Neill & Co., Ltd.

Transactions of the Royal Society of South Africa. Vol. XXIX. Part IV. pp. 279–283. September, 1942.

THE GENUS *AUSTROSPARUS* SMITH.

By J. L. B. SMITH.

(Read September 17, 1941.)

Family SPARIDAE.

During a revision of the Sparid fishes of South Africa (Smith, Trans. Roy. Soc. S.A., 1938, vol. xxvi, p. 241) the most difficult problem proved to be the reduction to order and uniformity of genera among the polymorphous forms generally grouped in the genus *Sparus* Linn. The views of previous workers had left the taxonomy of the species in a chaotic state, partly because of a number of intergradational difficulties. Eventually it was found (1938) that none of our species could be regarded as falling within the type genus *Sparus* Linn. Most were placed in other existing genera, while those most closely related to the Atlantic *Sparus* were grouped in a new genus, *Austrosparus*. The three species assigned to *Austrosparus* were *globiceps* Cuv., endemic, selected as the type, *sarba* Forsk., an Indian form, and *auriventris* Peters, a species previously regarded as of doubtful validity, based upon a brief and incomplete account of a Mozambique specimen. Previous workers had accepted *sarba* and *globiceps* as applying to South African specimens, the latter being a very characteristic species extending from the Cape to Natal. One of the commonest littoral and estuarine Sparids in South Africa had been identified (by previous workers) with the Indian *sarba* Forsk. During the 1938 revision it was found that among material identified (by previous workers) as *sarba*, two distinct species could be distinguished. One, common in Natal and farther north, rarely found south-west of the Kei River, was identified with *sarba* Forsk. The other, common on the south coast of Africa, and rare north of Durban, was eventually identified with the ill-defined *auriventris* Peters. The few characters mentioned in Peters's description applied to both *sarba* and the more southerly form, excepting only that *auriventris* was stated to have "On the belly each side above the ventrals a narrow golden longitudinal band" (Peters, Arch. Naturg., 1855, p. 243, translated by Fowler, 1933, U.S. Nat. Mus. Bull. 100, vol. 12, p. 179). The form found south of Natal has constantly a strong lateral golden band, whereas *sarba*, in the material I examined, had not. (Besides this difference there are others of more

weight which will be described below.) In consequence, it was decided (1938) to identify our specimens with *auriventris* Peters. Peters had assigned that species to *Diplodus* Raf., but it was obviously more closely related to *Austrosparus*.

Since that time I have been fortunate in securing together in one locality (on the coast, south of the Umtata River) a graduated series of fresh specimens of each of the forms I had (1938) identified as *sarba* and as *auriventris*. *Sarba*, when fresh, proves to have a bright golden band slightly obliquely up from the ventral base along the belly, and a faint bronze-yellow narrow line along each scale-row from the dorsal to the mid-ventral area. The other species has a strong medio-lateral golden band and only faint scale-row stripes. With this material, further study of Peters's description makes it quite clear that his *auriventris* applies to the form now identified with *sarba* Forsk., and not to the more southerly form. This latter cannot be identified with any known species, and thus becomes *Austrosparus tricuspidens* sp. n., endemic.

Genus *Austrosparus* Smith.

1938, Smith, Trans. Roy. Soc., vol. xxvi, p. 241.

Fowler (U.S. Nat. Mus., 1933, Bull. 100, vol. xii, p. 178) had made *auriventris* Peters the type of the sub-genus *Rhabdosargus* Fowler in *Diplodus* Raf. In the 1938 revision (Smith) this sub-genus had been transferred to *Austrosparus*, monotypic, with amended diagnosis. Since it is now shown that *auriventris* Peters is almost certainly a synonym of *sarba* Forsk., *Rhabdosargus* may be discarded, because *globiceps* and *sarba* do not differ by even sub-generic rank. The very characteristic features of the tricuspid teeth in juveniles and early adults of *tricuspidens* sp. n., and the scaled preopercle flange, still justify expression by at least sub-generic rank of the difference from *globiceps* and *sarba*. The new sub-genus *Prionosparus* for this form is proposed.

Key to the Species of Austrosparus.

1. (*Austrosparus*.) Preopercle flange naked. Incisors even in juveniles with entire edge.
    - A. Adult with cross-bars. Pectoral 1·1 times head. Anterior incisors chisel-edged. South coast of Africa, rare in Natal . *globiceps*.
    - B. No cross-bars in adult. Pectoral 1·3–1·4 times head. Anterior incisors lanceolate. Rare south of Natal . . . . . *sarba*.
2. (*Prionosparus*.) Preopercle flange with a few scales. Anterior incisors tricuspid in juveniles . . . . *tricuspidens*.

Sub-genus *Austrosparus* Smith.

Austrosparus globiceps (Cuvier).

1938, Smith, *loc. cit.*, p. 243.

There is nothing of importance to be added to the above description.

Austrosparus sarba (Forsk.).

1835, Ruppell, Neue Wirbel., p. 110, pl. xxviii, fig. 1.

1855, Peters, Arch. Naturg., p. 243 (*Diplodus auriventris*, Mozambique).

1861, Castlenau, Mem. Poiss. Afrique Aust., p. 25 (*Chrysophrys natalensis*).

1875, Day, Fishes India, p. 142, pl. xxxiv, fig. 6 (*Chrysophrys s.*).

1917, Gilchrist and Thompson, Ann. Durban Mus., vol. i, p. 361 (*natalensis*).

1927, Barnard, Ann. S.A. Mus., vol. xxi, p. 687 (*Sparus sarba*, part).

1933, Fowler, U.S. Nat. Mus. Bull. 100, vol. xii, p. 149 (*Sparus sarba*, part).

1934, Fowler, Proc. Ac. Nat. Sci. Phil., vol. lxxxvi, p. 470 (*bifasciatus*).

Day (*loc. cit.*) describes a species *Chrysophrys haffara* which is stated to differ from *sarba* Forsk. only in having slightly weaker anal spines and in minor variations in colour. These differences do not appear to justify distinction, since both are as a rule inconstant and of little significance. Dark shades and markings are very variable in estuarine fishes.

This Indo-Pacific form (*sarba*) appears to be widely distributed in the tropical and sub-tropical zones. I have not been able to examine a specimen from the type locality (Red Sea), but from a careful analysis of descriptions of specimens from over a wide area it would appear that the species is fairly constant, showing only little variation. Specimens from the Cape, Natal, Zululand, and Portuguese East Africa show almost no variation themselves, and all agree very closely with the diagnosis of Indian *sarba* Forsk. Apparently none of the northern and eastern specimens from the Indian Ocean were observed to have the flaring golden band on the belly (characteristic of *auriventris* Peters), but this would not have been remarked in preserved material, as the band fades rapidly after death. *Auriventris* Peters differs from the typical *sarba* (as described) only in the presence of the golden band on the belly. Preserved specimens, originally undoubtedly *auriventris*, are now indistinguishable from older material identified as *sarba*.

In the waters of Zululand and farther north, *sarba* attains a length of 500 mm. and is esteemed as a game fish. With growth the anterior

incisors thicken and shorten so as to be almost conical in large adults. They are never caniniform, nor at any stage as typically chisel-edged as those of the other species of the genus. *Sarba* has been found to extend as far south as the Bashee River; beyond that, westwards, the species is rare, but large specimens sometimes reach as far west as Mossel Bay, several generally being taken each year in the late summer at Knysna.

Sub-genus *Prionosparus* nov.

Austrosparus tricuspidens sp. nov.

1927, Barnard, Ann. S.A. Mus., vol. xxi, p. 687 (*sarba* Forsk., part).

1938, Smith, Trans. Roy. Soc. S.A., vol. xxvi, p. 247, pls. xviii, xxiii, and text-figs. 1, 7, and 8 (*auriventris*).

Types from Knysna in the Albany Museum.

This species agrees very closely in general form and structure with *A. sarba* Forsk. It may, however, clearly be distinguished at all stadia. In fresh material, *A. sarba* has the golden band along the belly originating from the ventral base; *A. tricuspidens* has a longitudinal median golden band originating above the pectoral base and running straight along the middle of the side to the caudal base. In preserved material of juveniles and adults up to 150 mm. in length the teeth are immediately diagnostic. The anterior incisiform teeth of *A. tricuspidens* are apically dilated and sharply tricuspid; those of *A. sarba* are long, slender, and pointed, but still clearly incisiform. In all stadia of preserved material the scales on the preopercle flange of *A. tricuspidens* are diagnostic. These vary in number and position, but the presence of only one is sufficient, since the preopercle flange of *A. sarba* is invariably quite naked. Also *A. sarba* has markedly longer pectorals (1·3–1·4 times head), which when folded forward extend well beyond the snout tip, while in *A. tricuspidens* the pectorals (1·1–1·2 times head) when so bent reach scarcely, if at all, beyond the snout tip. *A. globiceps* may clearly be distinguished from the other species by the absence of the golden band in all stadia. In juvenile stadia the anterior incisors of *A. globiceps* are chisel-edged and entire, and are distinguishable at a glance from the more acute shape in *A. sarba* and from the tricuspidation of *A. tricuspidens*. In *A. globiceps* the preopercle flange is naked, and dark cross-bars are present in all stadia.

A. tricuspidens is common in all tidal estuaries from the Cape Peninsula to the Kei River. It is particularly abundant in tidal rivers from Knysna to East London. Farther north it gradually diminishes in numbers, mingling with, and being progressively replaced by, *A. sarba* Forsk. *A. tricuspidens* rarely exceeds 350 mm. in length and appears to prefer estuaries to the open sea. Although small in size, its flesh is highly esteemed.

The following are the common names of the three species:—

globiceps: White stumpnose (Cape); Stumpnose (general); Go-home fish (Tzitzikama–Plettenberg area).

sarba: Silver bream (Natal).

tricuspidens: Blink-vis (Port Beaufort); Stompneus or Stumpnose (Knysna); Flatty (Eastern Province); Silvie (East London); Silver bream (Natal).

I wish to express my gratitude to the National Research Board of South Africa for financial assistance.

ALBANY MUSEUM,
GRAHAMSTOWN,
August 1941.

Transactions of the Royal Society of South Africa. Vol. XXX. Part I. pp. 49–57. June, 1943.

INTERESTING EARLY JUVENILE STADIA OF CERTAIN WELL-KNOWN SOUTH AFRICAN FISHES.

By J. L. B. Smith.

(With three Text-figures.)

(Read March 18, 1942.)

During a revision of the Sparid fishes of South Africa (Smith, Trans. Roy. Soc. S.A., 1938, vol. xxvi, pp. 225–305), the genus *Chrysoblephus* Swainson, which had not been accepted by most workers, was restored to full rank. In that genus were placed four well-established species, as well as two others which had not been accepted by Barnard (Ann. S.A. Museum, 1927, vol. xxi, pp. 698 and 700). These, *puniceus* G. and T. and *lophus* Fowler, were found to be valid species and to fall in *Chrysoblephus*. The case of *C. puniceus* (G. and T.) was particularly interesting because of the close relationship of that Natal species with *C. cristiceps* (Cuv.) of the southern Cape. The two species evidently have similar habits and the same type of habitat, *i.e.* rocky shelves or reefs in fairly deep water, but there is an almost sharp line of demarcation between the areas where they occur. *C. cristiceps* is typical of the southern Cape, extending from Cape Town eastwards to East London, becoming rapidly less frequent farther north, and being comparatively scarce at Durban. *C. puniceus*, on the other hand, is found only very seldom south of the Kei River, and has recently been observed (Smith, Trans. Roy. Soc. S.A., 1940, vol. xxviii, p. 176) to become progressively more abundant, and of greater average size, as far north as Beira.

In only very few cases is anything known about the reproduction or the developmental stadia of even our commonest fishes of angling or commercial importance, which live in or about reefs in fairly deep water. Recently the cold current (temperature 10° C.) which occasionally appears off the coast of Knysna, and which causes high mortality among small and juvenile fishes, has enabled me to secure hitherto unknown stadia of several well-known species. In particular this material covers juveniles of *Chrysoblephus puniceus* (G. and T.) and of *C. cristiceps* (Cuv.), which differ most markedly from the adult stage in the markings on the body. The juveniles show clearly not only how closely the two species are related, but

also that they are clearly distinct. It may be noted that in view of the distribution of the adult, the appearance of the juvenile *puniceus* at Knysna is remarkable, but whereas many hundreds of juvenile *cristiceps* were thrown up, only two specimens of *puniceus* were found. In both cases the striking difference in markings from the adult is worthy of special note.

Chrysoblephus cristiceps (Cuv.).
(Text-fig. 1.)

Smith, Trans. Roy. Soc. S.A., 1938, vol. xxvi, p. 264, pls. xx and xxvi, and text-fig. 14.

Early Juvenile Stadia.—Proportions given in brackets are those of the adult stage.

Body oblong-ovate, highly compressed. Dorsal profile gently undulate, very slightly concave at nape. Depth 2·3 (Ad. 2·2), length of head 3·1 (2·9)

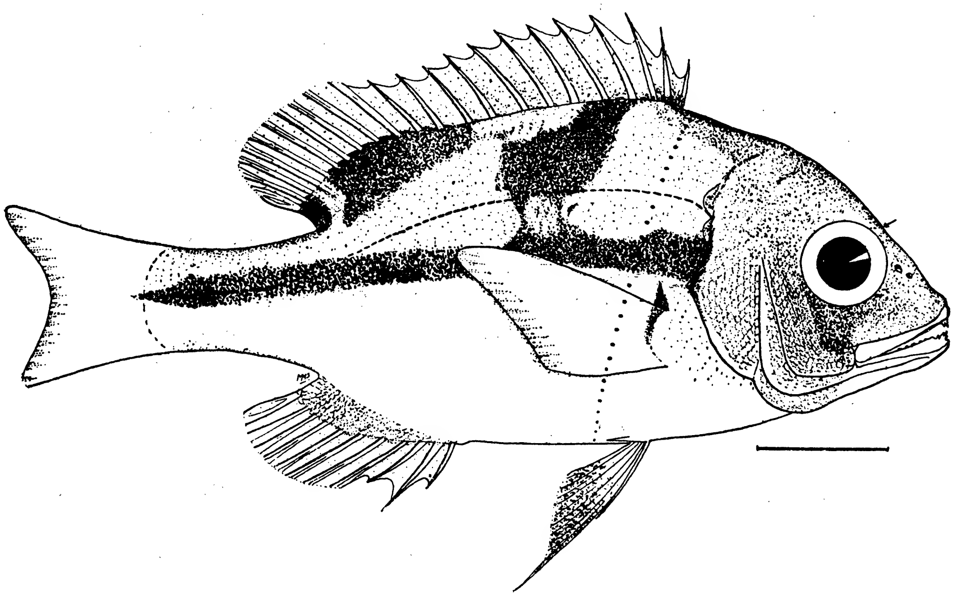


FIG. 1.—*Chrysoblephus cristiceps* (Cuv.). Juvenile.
The line represents 1 cm. The small arrow shows anterior margin of scaling on head.

in length of body. Eye 3·0 (5·0), snout 3·9 (2·4), interorbital 3·6 (3·6), and postorbital part of head 2·3 (2·5) in length of head. Preorbital depth 2·1 (0·9) in eye. Lower margin of preorbital entire, straight. Preopercle margin entire, smooth. 9–10 gill-rakers on lower limb of anterior arch,

anterior rakers very short, increase graduated posteriorly. Posterior nostril only slightly oval.

Mouth moderate, terminal, jaws equal, maxilla extends to below anterior margin of pupil. Extremity of maxilla well exposed. Anteriorly 6 acute canines in each jaw, outer on each side moderate, inner small. The inner series of molariform teeth characteristic of the adult stage (2 series) are not developed. The outer lateral teeth (molariform in adult) in a single series are obtusely conical and somewhat uneven in size. These form a lateral cutting edge.

D XII, 10, spines fairly stout, 4th or 4th and 5th longest, 2·6 (2·4) in head. Soft rays longer than posterior spines, longest 2·0 in head, edge of soft fin gently convex. A III, 8, 2nd spine much longer and stronger than 3rd, soft fin gently convex. Pectoral 1·2 (1·1) in head, reaches to anal origin. Ventral 1·3 (1·5) in head, 1st ray filamentous, reaches beyond anal origin. Caudal feebly emarginate, emargination increases with growth.

Scales strongly ctenoid, l.l. 61, l.tr. 9/19. Lateral line tubes short and stout. 11 cheek scales. Interorbital scaly, scaling extends to above anterior margin of eye. Preopercle flange almost completely scaly, only extreme margin naked. Ctenae on scales much coarser than in adults. Soft dorsal and anal with heavy basal scaling extending 1/3 length of rays.

Colour.—Ground colour faint rosy. A black lateral stripe, about $\frac{1}{2}$ eye diameter in width, from caudal base along middle of side to hind margin of opercle. A black anterior dorsal blotch from below the 3rd–5th dorsal spine broadening irregularly inferiorly and posteriorly, contracting below, and in most specimens joining the lateral stripe by a narrow isthmus below the 7th–8th dorsal spines. A second black cuneate dorsal blotch, twice as long as deep, extending along the bases of the three posterior dorsal spines and of the first six dorsal rays, which covers the basal scaly sheath of the soft dorsal. A posterior black dorsal blotch at the base of the last two dorsal rays. A very distinct black blotch in and upwards of the pectoral axil. Nape, interorbital, snout, and cheek dusky. Dorsal and anal faint dusky. Caudal with dusky margin. Pectoral light. Ventral dark-dusky. Iris bronzy. This colour pattern is invariable save in minutiae among many specimens.

Length.—50–70 mm.

Locality.—Shores of the Knysna estuary, thrown up dead, February 1941.

Common Name.—Dageraad (Cape generally).

These juvenile fishes were at first not easy to recognise as *cristiceps*, but detailed study leaves no doubt as to their identity. The striking colour-pattern differs markedly from that of the almost uniform adult,

in which only the posterior basal spot on the dorsal and the axillary pectoral spot persist. Other differences from the adult are to be found in the dentition, *i.e.* absence of interior molars, in the filiform first ventral ray, in the lesser emargination of the caudal, and in the stronger ctenation of the scales. Scales from various specimens (50–70 mm. length) show no sign of annulation in the circuli. This would indicate that fishes of that size are probably in the second year of growth. I have observed ripe females of *cristiceps* in October, which would appear to confirm this. These small fishes have never been observed in rock-pools over many years of collecting, so that it may be presumed that they inhabit reefs in deeper water (the adult habitat). The early larval stadia are unknown.

Chrysoblephus puniceus (Gilchrist and Thompson).

(Text-fig. 2.)

Smith, Trans. Roy. Soc. S.A., 1938, vol. xxvi, p. 265, text-fig. 15.

Early Juvenile Stadia.—Proportions given in brackets are those of the adult stage.

Body oblong-ovate, very compressed. Dorsal profile evenly convex from nape, snout steep. Depth 2·2 (2·0), length of head 3·2 (3·3) in length of body. Eye 3·0 (3·8), snout 3·7 (2·5), interorbital 3·3 (3·3), and postorbital part of head 2·2 (2·7) in length of head. Preorbital depth 1·6 (1·0) in eye. Lower margin of preorbital entire, straight. Preopercle margin with signs of slight serrae round the angle. 14 gill-rakers on lower limb of anterior arch, anterior rakers very short, increase in length posteriorly Posterior nostril oval.

Mouth terminal, small, jaws subequal, maxilla extends to below centre of eye. Maxilla largely concealed, extremity slightly exposed. In upper jaw anteriorly 4–6 acute caniniform teeth of moderate size, the outer 2 pairs subequal, the inner pair when 6 present very small. 6–8 similar anterior canines in the lower jaw, usually two very small symphysial teeth, the outer 2 on each side larger, subequal to those in the upper jaw. In one case on each side one smaller canine. On each side in each jaw a lateral series of obtusely conical teeth corresponding with the outer lateral molars of the adult. No inner molariform teeth, although faint granulations are visible on the inner upper surface of the dentary.

D XII, 10, spines fairly stout, 4th and 5th subequal, longest 2·1 (2·1) in head. Soft rays longer than posterior spines, longest 2·4 in head, edge of soft fin gently convex. A III, 8, 2nd and 3rd spines subequal, 2·6 in head. Soft fin gently convex. Pectoral 1·1 (1·2) times head, reaches to above the origin of the soft anal. Ventral almost length of head, reaches

beyond anal origin, 1st ray filamentous. Caudal slightly emarginate, emargination increases with age.

Scales strongly ctenoid, l.l. 52, l.tr. $\frac{10}{18}$, lateral line tubes very short and stout. 8 cheek scales. Interorbital scaly, scaling extends to in advance of above anterior margin of eye. Preopercle flange scaly, only

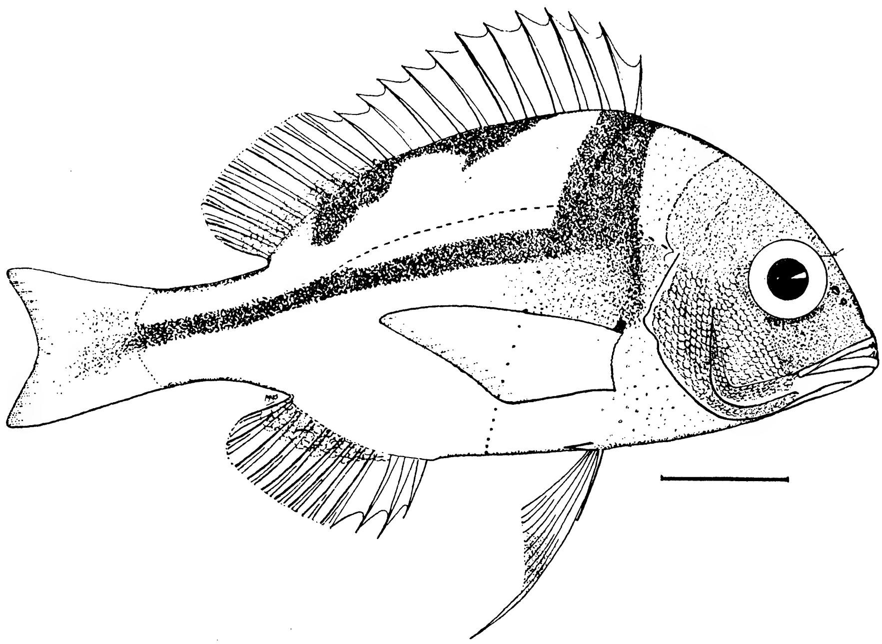


FIG. 2.—*Chrysoblephus puniceus* (Gilchrist and Thompson). Juvenile. The line represents 1 cm. The small arrow shows anterior margin of scaling on head.

extreme inferior margin naked. Ctenae on scales relatively coarser than in adults. Basal scaling to soft dorsal and anal not very dense, not as heavy or of as great extent as in *cristiceps*.

Colour.—Ground colour faint rosy-pink. A black lateral stripe less than half eye-diameter in width from the middle of the caudal base forwards and slightly upwards along the side almost to the origin of the lateral line. At its anterior end it merges with the longer lower margin of an anterior trapeziform dark dorsal blotch which originates from slightly in advance of the dorsal, and extends to the base of the 3rd dorsal spine. The mark expands inferiorly. A second posterior irregular dark blotch runs along the dorsal profile from the base of the 4th–5th dorsal spine to the middle of the base of the soft dorsal, expanded postero-ventrally. Nape, snout, and cheek faintly dusky. A faint horizontal suborbital bar. Dorsal very faintly dusky marginally. Other fins light.

Length.—55–65 mm.

Locality.—Shores of the Knysna estuary, thrown up dead, February 1941.

Common Name.—Slinger (Natal).

It is remarkable to find these very young specimens some hundreds of miles south-west of the normal southerly limit of the area in which the adult of *puniceus* occurs. There is no question of their identity as *puniceus*. Although strikingly different from the adult in colour-pattern, every character of importance confirms them as that species. The colour-pattern is similar to that of *cristiceps*, but the anterior dorsal blotch is further forward and more regular in shape in *puniceus*, while the dark mark at the hind margin of the dorsal base, characteristic of *cristiceps* at all stadia, is absent. Besides the colour pattern, the young differ from the adults in various other features, *e.g.* dentition, filiform ventral ray, ctenation of the scales, and less deeply incised caudal. With age the body changes to the triangular shape of the adult with the nuchal region elevated.

In so far as may be judged from the scales these fishes are between 1 and 2 years of age.

Fowler (Proc. Ac. Nat. Sci. Phil., 1935, vol. lxxxvii, p. 390, fig. 23) listed a fish, 70 mm. in length, taken from the stomach of a "Steenbras" (Durban), as *Dentex filosus* Valenciennes. In 1938 (Trans. Roy. Soc. S.A., vol. xxvi, p. 298), not having seen an actual specimen, I considered Fowler's specimen to be more likely a juvenile of *Polysteganus undulosus* (Regan). Since I have seen the specimens described above, there is no doubt that Fowler's specimen was a juvenile *C. puniceus*, although his figure (*loc. cit.*) shows a body shape quite unlike that of my specimens. The markings are, however, quite definitely diagnostic.

Family DENTICIDAE.

Polysteganus undulosus (Regan).

Smith, Trans. Roy. Soc. S.A., 1938, vol. xxvi, p. 298, pls. xxi and xxviii and text-fig. 23.

This species, known by the common name of "Seventy-four," was at one time quite abundant in the Mossel Bay–Plettenberg area. In recent years it has become progressively scarcer, so that specimens are rarely encountered. It is therefore of considerable interest that relatively large numbers of juveniles, 45–60 mm. in length, should have been thrown up dead at Knysna during an onset of cold water (10° C.) in February 1941.

This species is easily recognisable at a glance by the 5–6 narrow longitudinal wavy blue lines along the sides, which are present in even the earliest stadia (45 mm. length). These juveniles differ from the adults

chiefly in the following characters: the median blue-black blotch on the lateral line observed in later stadia is not present in small juveniles. The body of the juvenile is relatively more elongate, the dorsal profile much flatter, and the snout more sharply conical than those of the adult. The caudal is much less deeply excised in the juvenile. The preopercle flange is smooth in all stadia. The chief changes with growth are a gradual elevation of the nuchal region, producing a deeper body and a steeper snout, even to the extent of a frontal gibbosity in large adults. The caudal becomes more deeply forked with age.

Family DICHISTIIDAE.

Dichistius capensis (C. and V.).

(Text-fig. 3.)

Smith, Trans. Roy. Soc. S.A., 1935, vol. xxiii, p. 269, pl. xiii.
Ibid., 1938, vol. xxv, p. 389, pl. x (early post-larval stadium).

Nothing was known about the early stadia of this species until the post-larval specimen, 22 mm. in length, was described (above). Since that time other graduated specimens have been obtained which show the transition to the adult stage. Unfortunately specimens are obtained only by chance so that the complete transition could not be shown in one paper. The following is a description of a specimen, 36 mm. in length. Considerable changes have occurred when compared with the 22-mm. stage. Dorsal profile moderately steep, evenly convex from nape. Body elongate-oval, highly compressed. Depth 2·4, length of head 2·9 in length of body. Eye 2·6 in head. Preorbital depth 2·1 in eye. Preopercle margin strongly serrate, with two largest spines at angle.

Mouth terminal, small, horizontal, lower jaw projects slightly. Maxilla well exposed, extends to below anterior margin of eye. In the upper jaw the anterior teeth are almost exsert, rather elongate, curved, acute, incisiform, about 14 in the outer series. Behind the outer series are 2–3 rows of smaller similar teeth in an anterior patch. In the lower jaw the teeth are almost exsert and oblique, and the anterior teeth across the symphysis are elongate and incisiform, but not as acute as those in the upper jaw. There are 12 larger teeth anteriorly, and on each side 5-6 smaller fine teeth laterally. Behind the anterior teeth no other teeth can be observed. Gill-membranes scarcely united, free from isthmus.

D X, 18, 4th spine longest, 2·5 in head, 9th and 10th spines subequal, 2/3 of 4th. First ray twice length of last spine, the anterior rays elevated, forming a lobe. Edge of soft fin undulate, concave behind anterior elevation. As compared with the 22-mm. stage, the spinous dorsal is

unchanged, whereas the anterior soft rays are relatively longer. A III, 13, anterior rays elevated, 1·8 in head, forming a lobe. Edge of fin gently concave. Pectoral 1·4, ventral 1·5 in head, latter does not reach vent. Caudal slightly emarginate. Scales very thin, almost impossible to count with accuracy. Basal scaling of dorsal and anal much less than in adult stage, not 1/5 of total height of rays.

Colour.—Predominantly dark-dusky above, silvery grey below, each area produced to form alternate dark and light cross-bars. From the

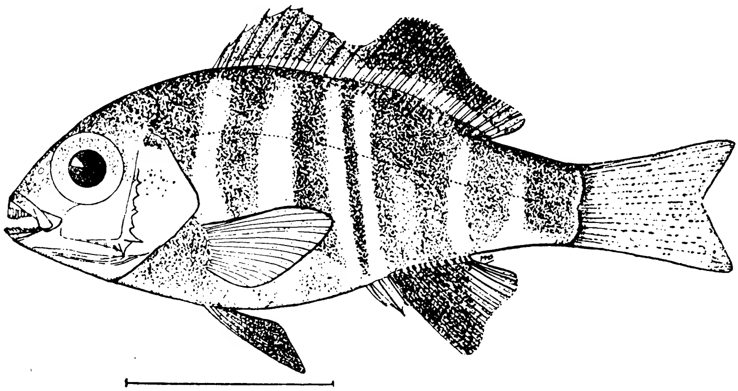


FIG. 3.—*Dichistius capensis* (C. and V.). Juvenile. 36 mm. The line represents 1 cm.

snout to the origin of the dorsal fin is dark, thereafter alternated 6 light and 6 dark cross-bars, the light cross-bars extending just short of the dorsal profile, and most of the dark bars just short of the ventral. The fourth dark cross-bar is the widest, and is continuous over the anterior part of the anal fin. (This pattern is slightly different on the other (r.h.) side of the specimen, the bars varying in width.) Dorsal distally dark, with a light bar running along the base of the spines and rays just above the body. The anterior rays darkest. Anal anteriorly very dark, only the few hinder short rays light. Pectoral and caudal light. Ventral dark.

Locality.—Cape Seal. A rock pool at low tide mark, early December 1941.

The 22-mm. stage described earlier (Smith, 1938, *loc. cit.*) was presumed to be about 6 weeks old, having been taken in September. The 36-mm. stage described above, taken in early December, is probably about $3\frac{1}{2}$ months old. Very considerable growth changes have taken place from the 22-mm. to the 36-mm. stage. The body has deepened, with great alteration in the shape of the head, the mouth has changed from oblique to horizontal, the earlier cuspidation of the incisors has disappeared, the

caudal has become more deeply emarginate, and the anterior dorsal and anal rays more elevated. The 36-mm. stage is much more like the adult, differing chiefly in the presence of the preopercular spines, in the less deeply incised caudal, and in the lesser elevation of the soft dorsal and anal rays. The teeth are much more acute than those of the adult.

A specimen 58 mm. in length was obtained in the same locality (Cape Seal) in April. The chief variations from the 36-mm. stage are: the anterior dorsal and anal rays are more elevated, the caudal is more deeply forked, the anterior incisiform teeth have the distally dilated curved shape of those of the adult, and the preopercular spines are markedly smaller, though very distinct, and the body is deeper, 2·3 in length. The body bears 8 dark cross-bars alternated with light areas of equal width.

The principal growth changes in *Dichistius capensis* may thus be summarised:

	22 mm.	36 mm.	58 mm.	Adult up to 500 mm.
Depth in length .	2·9	2·4	2·3	2·2
Eye in head . .	2·5	2·6	3·0	3·8–5·0
Preopercle margin .	Strongly serrate.	Serrate.	Serrate.	Smooth.
Caudal . . .	Truncate.	Feebly emarginate.	Emarginate.	Deeply emarginate.
Anterior dorsal rays in head.	3·5	2·3	2·0	1·7
Anterior teeth . .	Cuspidate.	Pointed.	Rounded.	Rounded.

I wish to express my gratitude to my wife for the illustrations and to the National Research Board for financial assistance.

ALBANY MUSEUM,
GRAHAMSTOWN,
February 1942.

Transactions of the Royal Society of South Africa. Vol. XXX.
Part I. pp. 67–77. June, 1943.

INTERESTING NEW FISHES OF THREE GENERA NEW TO SOUTH AFRICA, WITH A NOTE ON *MOBULA DIABOLUS* (SHAW).

By J. L. B. Smith.

(With three Text-figures.)

(Read May 20, 1942.)

Family GOBIESOCIDAE.

Eckloniaichthys, genus nov.

Body fairly elongate, head not broad, little depressed. Dorsal and anal fins sub-opposite, remote from caudal, of few rays, hind margins free from body. Posterior segment of disc without free anterior margin, the two segments connected by an isthmus. No opercular spine. Teeth all incisiform, uniserial in each jaw.

By the combination of the unusually slender body, anterior insertion of dorsal and anal, incisiform teeth, and absence of a free margin to the anterior portion of the posterior segment of the disc, *Eckloniaichthys* is clearly distinguished from all other genera. Its nearest ally appears to be *Trachelochismus* de Barneville, from New Zealand, which has a similar anterior insertion of the vertical fins, but which has a much more robust depressed body, and no incisiform teeth, while the posterior lobe of the disc has an anterior free margin.

Eckloniaichthys scylliorhiniceps, sp. et gen. nov. (fig. 1).

Body sub-cylindrical, at most but slightly depressed at nape, highly compressed posteriorly. Dorsal profile very gently sloping from nape, snout pointed in profile, shape of head distinctly "Selachian." Head fairly depressed, with interorbital only slightly convex. Skin rough, densely beset with fine tubercles which cover the whole head and body, and extend almost to the extremity of the caudal fin. Eye covered with skin, and better visible from below than from above.

Maximum depth at shoulder 7·2, length of head 3·7 in length of body. Eye 3·8, snout 3·2, interorbital 2·1, and postorbital part of head 2·2 in length of head. Maximum width of head 1·5, maximum depth of head 2·2 in length of head.

Nostrils fairly close together at the anterior margin of the orbit, the anterior with a plain circular pedunculate flap. Several series of distinct pores on head. Gill-membranes united, folded across throat, apparently quite free from isthmus.

Disc of two distinct portions, originates below an eye diameter behind orbit. Total length of disc 2·0 in head, and it is 1·5 times longer than wide. Anterior segment almost regularly hexagonal, slightly wider than long. Posterior segment about 1·3 times wider than long. The two segments

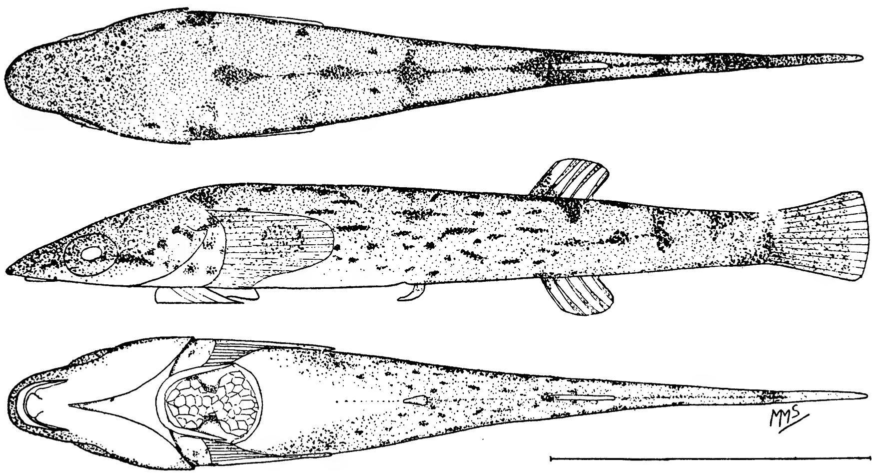


FIG. 1.—*Eckloniaichthys scylliorhiniceps* n.g. et sp.
Above: Dorsal view. *Middle:* Lateral view. *Below:* Ventral view.
The line represents 1 cm.

connected by an isthmus of moderate width. The floor of the disc is composed largely of horny plates of various shapes, mostly angular approximating to the hexagonal shape. Posterior segment of disc without anterior free margin. The hinder flange of the coracoid segment is continued forwards and upwards beneath the pectoral, being fused with the base of that fin for the basal two-thirds of its depth.

Mouth small, inferior, lower jaw entirely included in upper. The snout projects over the upper jaw in the form of a fleshy fold. There is a fairly thick plain continuous lip to the upper jaw. That of the lower jaw is trilobate, the central lobe being much the largest. The cleft of the mouth is almost rectangular, and extends 4·5 in the length of the head, about equal to the eye, and reaches below slightly beyond the anterior margin of the orbit. Teeth all incisiform. In the upper jaw there is a single series of about 14 slightly curved incisors, which become larger and slightly lanceolate anteriorly. No other teeth visible. From the symphysis

backwards there extends a ⊥-shaped narrow ridge which appears to bear minute asperities, but owing to the small size of the specimen this is difficult to establish. In the lower jaw a single series of 12 incisiform teeth which increase in length and are of more oblique insertion anteriorly. The anterior teeth are apically somewhat dilated with the upper edge cut to a very obtuse point, but they are not lanceolate. No conical teeth of any kind, nor any teeth behind the single outer series in each jaw.

D 5, inserted 2·2 times farther from the snout tip than from the caudal base, almost exactly midway between the hind margin of the head and the hind edge of the caudal. Base about 3·4 in head. The first ray does not appear to be articulated, but is quite soft. All the rays are simple. Hind margin of fin free from body. The 2nd and 3rd rays are the longest and sub-equal, about the length of the base of the fin. Edge of fin gently convex. A 5, inserted slightly behind dorsal, about midway between hind edge of caudal and pectoral base. In structure and size the fin is almost exactly the same as the dorsal. P 17, 6·0 in length of body, 1·9 in head. Base very heavy, extending over almost $\frac{3}{4}$ of the body depth. The upper longer portion of 11 simple rays, the lower shortened flange of 5 rays shortening ventrally, and all simple. There are 4 ventral rays, and no sign of a dorsally embedded spine. The hinder ventral ray extends almost to the posterior margin of the disc. Caudal rays 12, 7·7 in body length, 2·1 in head, almost truncate, with rounded edge, rays all simple.

Body entirely scaleless.

Colour.—When alive, dark green-brown, with a bar through the eye, and numerous red-brown streaks on the body. With preservation the colour changes to an orange-red, and the streaks to bright dark red. Ventral surface of head and disc light. Dorsal and anal light russet. Pectoral light distally. Caudal body colour with posterior light margin.

Length.—27 mm.

Locality.—10 miles west of East London.

Type, a male, apparently adult, in the Albany Museum.

This very interesting fish was taken among a dense growth of the sea-bamboo—*Ecklonia*—in a rock-pool at the lowest ebb of an exceptionally low spring tide. The colour pattern of the fish rendered it practically invisible in or on the *Ecklonia.* It is at first sight rather surprising that so sluggish a type of littoral fish should remain so long unknown. It is probably to be ascribed to the fact that this species doubtless never leaves the shelter of the sea-bamboos which generally extend little, if at all, above the lowest ebb of the tides. It may be noted that in the same pool in which this specimen was taken there were numerous specimens of *Chorisochismus dentex* Bl. Schn. on the rocks below. The incisiform teeth of *E. scylliorhiniceps* indicate a mode of life different from that of *C. dentex,*

which with its large conical teeth is obviously predatory and carnivorous.

Family GOBIIDAE.

Genus Taenioides Lacep.

An Indo-Pacific genus of degenerate forms, mostly quite blind, not previously recorded from South Africa.

The South African species, *jacksoni* n.sp., has two distinct dermal coverings. The outer envelops all the structures including the fins and the dermal bones of the head, and has obviously been developed in response to the mode of life of these creatures. Both skins bear chromatophores, but they are more plentiful in the inner coat.

Taenioides jacksoni sp. nov. (fig. 2).

Body elongate, eel-like, sub-cylindrical anteriorly, slightly more compressed in caudal region. Maximum depth at shoulder, body tapers regularly posteriorly. Head fairly compressed, interorbital only faintly convex. Depth anteriorly 11·2, length of head 7·1 in length of body. Depth at caudal base about $\frac{1}{4}$ depth at shoulder. Minute rudimentary obsolescent eyes beneath skin. Interorbital 5·5, snout 3·2, preorbital depth 6·0 and postorbital part of head 1·5 in length of head.

Numerous fine papillae or tentacles on head, longest on snout, above and around nostrils in small groups. A number in the preorbital and suborbital regions, the lower margin of the suborbital bearing a fringe of tentacles. A half-circle of 4–5 behind each eye. A group behind the hind end of the maxilla. Several scattered over the preopercle, the lower margin of which bears a fringe of papillae. A number on the opercle irregularly clustered towards the hinder lower region. A number of rather small papillae in a patch across the symphysis of the lower jaw. The lower margin of the ramus of the lower jaw bears an irregular fringe of somewhat larger tentacles. Of apparently numerous sensory canals on the head, an arborescent suborbital branch is most marked.

The externally visible outlines of the myomeres show from the shoulder, curving gently down to the middle of the side, thence to the caudal base. There are 25 simultaneous parallel superior and inferior retrorse branches which (except for those on the belly which do not reach the ventral profile) run to the dorsal and the ventral margins of the body. Before the apex of each furcation on the middle of the body is a vertical series of 3–5 fine cirri much like those of the head (fig. 2, C).

Mouth terminal, slightly oblique, lower jaw protrudes slightly. Maxilla exposed, extends just behind eye, total length from snout tip 2·4 in head

(3·4 in profile). Moderate curved fang-like teeth in apparently a single series round each jaw, difficult to count, about 20 in each jaw, longest scarcely 5 in maxilla length. No other teeth can be ascertained.

Gill-membranes broadly fused with isthmus. Gill-openings restricted to one lateral aperture, of vertical depth about 4 in length of head. Only

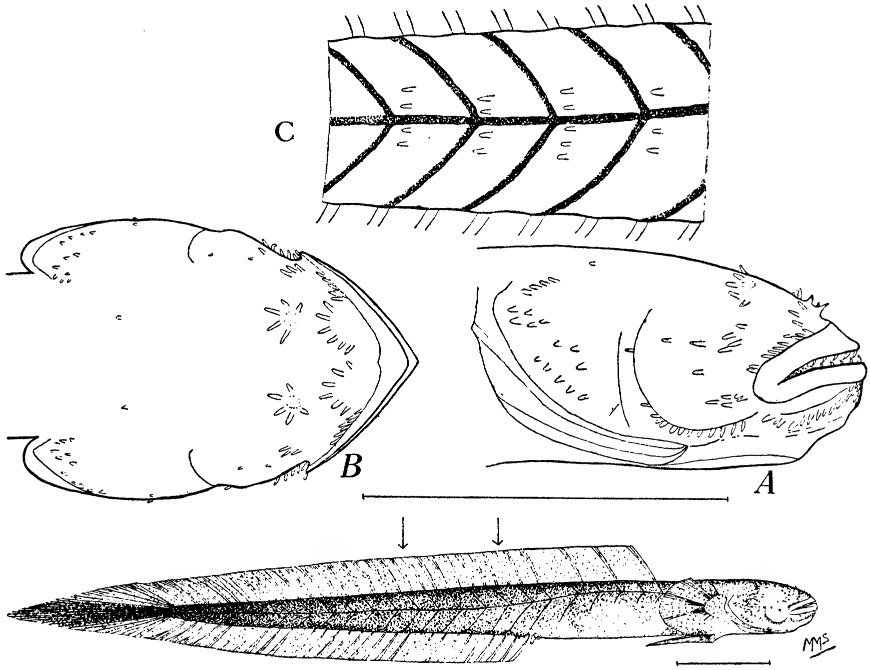


FIG. 2.—*Taenioides jacksoni* sp. nov.

Below: The complete animal, lateral view. The line represents 1 cm. The two arrows indicate the portion of the body shown enlarged in C above.

Above: The line represents 1 cm. A. Head, side view. B. Head, dorsal view. C. Side of body showing lateral tentacles.

3 branchiostegal rays visible. Gill-rakers small tubercles, increasing posteriorly, 7 on the lower limb of the anterior arch. Pseudobranchiae present.

Dorsal and anal confluent with caudal, rays covered by thick skin, very difficult to count or to examine. D 33–34, originates slightly in advance of hind margin of pectoral. First three rays widely spaced, about one-third head length apart, and from the fourth ray. Rays subequal, decrease very slightly posteriorly. Anterior rays 2·5 in head. A 30 inserted below the 4th dorsal ray, rays equally spaced, lower than the

dorsal rays, about 2·9 in head. Pectoral with lobate base, rounded, of 17 rays, 2 in head. Ventrals united, forming a disc, total length 1·2 in head. Caudal pointed, hastate, of 15 rays, 1·8 times head.

Scales entirely absent.

Colour.—Dark olive-brown, with close-set darker dendritic specks, densest dorsally, belly lighter. Fins lighter, greyish, except caudal, which is dark medially, lighter marginally. Myomere lines black.

Length.—Up to 90 mm.

Locality.—Shores of the estuary of St. Lucia, Zululand, living in burrows in the mud.

Type from St. Lucia in the Albany Museum.

Two specimens, one much shrunken, were obtained by Mr. W. T. Jackson, M.A., an enthusiastic and successful collector, after whom the species is named.

These peculiar degenerate blind Gobies have long been known from the tropical Indo-Pacific, and it is interesting to find a species on our shores. More intensive collecting will doubtless reveal that others are present also.

T. jacksoni appears to be clearly distinct from all other species by numerous features, notably in the nature of the dermal appendages.

Family BROTULIDAE.

This polymorphous family is fairly well represented in our waters, but it is only in recent years that the somewhat rarer forms with free caudal have been found here. The first to be described was *Bidenichthys capensis* Barnard, with lobate pectoral, and male organ without horny claspers. A specimen has recently been secured which appears to fall into the Australian genus *Dermatopsis* Ogilby, not previously found in South Africa. *Dermatopsis* is distinguished from *Bidenichthys* in that the pectoral fin is normal, and there are horny claspers in the male organ.

Dermatopsis kasougae sp. nov. (fig. 3).

Body fairly elongate, compressed, especially posteriorly. Snout blunt, almost cetacean. Dorsal profile gently sloping from nape. Depth 5·7, length of head 4·9 in length of body. Eyes small, lateral, covered by skin, 10·1 in head. Interorbital and snout sub-equal 5·0, and postorbital length 1·4 in head. The suborbital depth is slightly greater than the eye. Head fairly compressed, its greatest width one half of its depth. Head rather spongy and pitted, with small foliaceous lobes and convolutions about the snout. No barbels or cilia. Nostrils more or less tubular,

especially the anterior. Few distinct pores other than on the snout, but a few indefinite pits below the symphysis of the lower jaw. Preopercle margin beneath the skin. No obvious opercular spine, but a very obtusely angular hind margin well hidden by skin.

Mouth terminal, almost horizontal, jaws sub-equal. Maxilla extends almost two eye diameters behind eye, with a blunt spiniform projection on the lower margin near the hinder end. Teeth all acutely conical and fairly slender, all except those on the vomer are depressible. In the lower jaw the teeth form a band across the symphysis, in three series anteriorly

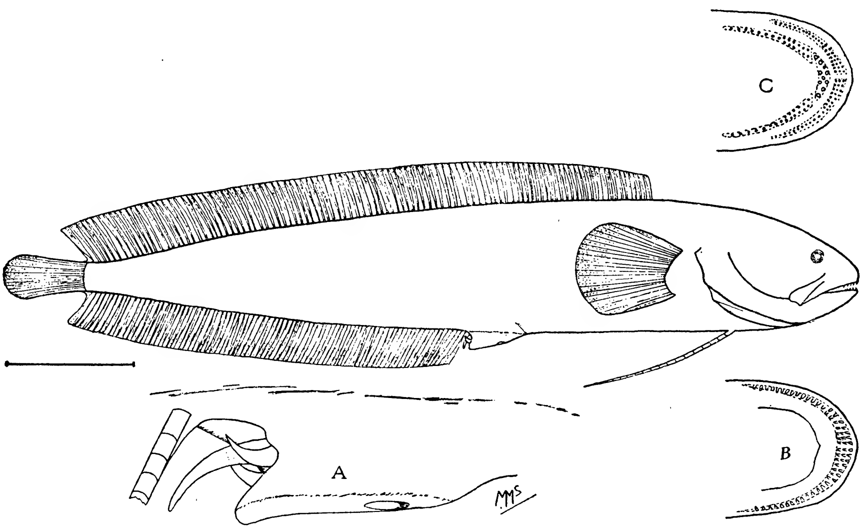


FIG. 3.—*Dermatopsis kasougae* sp. nov. The line represents 1 cm. A. Urogenital papilla, male, enlarged. B. Lower jaw, and C. Upper jaw, both enlarged, about × 4·2.

grading laterally to a single series which extends the full length of the dentary, about 42 in the outer series in all. In the upper jaw is a band of premaxillary teeth, triserial anteriorly, grading to a single lateral series, about 40 in the outer series in all. In the curved vomer are set 10 fairly large rigid conical sharp teeth. Each palatine bears anteriorly six rows of 2 teeth followed by a single series of 8. Pterygoids and tongue edentate. Tongue apically free, obtuse, with a median point.

Gill membranes narrowly attached to isthmus. Pseudobranchiae absent. A slit behind last gill. 12–13 gill-rakers on the lower limb of the anterior arch, merely low spiny tubercles.

The ventrals only are of simple rays, all other fin rays are divided. Dorsal and anal not confluent with caudal, but the basal axillary membrane

from the last ray of each attached narrowly to the base of the outer caudal rays. D 102, originates over the anterior third of the pectoral, almost three times farther from the hind margin of the caudal than from the snout tip. Base of dorsal 1·3 in length of body. The rays increase gradually posteriorly, the anterior being about 6·0, the posterior about 3·2 in length of head. A 86, originates almost exactly midway between the tip of the snout and the base of the caudal. Rays increase slightly in length posteriorly, the anterior being longer than the anterior dorsal rays, but the posterior are not as long as the posterior dorsal rays. P 22, 1·5 in head, tip reaches exactly half-way from the base of the fin to the origin of the anal fin. Each ventral of a single simple ray, as long as head, inserted twice as far from the origin of the anal as from the tip of the snout. Caudal free, rounded, 1·8 in head.

No trace of a lateral line can be discerned. The head is entirely naked. Minute very indistinct cycloid scales buried in a thick dermal layer over the whole body to the nape. It is only on the nape that they appear to be slightly diffuse, but, as far as may be observed, on the rest of the body they are normally and regularly imbricate.

Male urogenital structure large, with two fang-like horny claspers curving dorsally, with a long curved fleshy papilla between them curving ventrally. (See A, fig. 3.)

Colour.—Alive: Uniform light salmon-pink, fins light. On preservation the colour has faded to a uniform light buff.

Length.—70 mm.

Locality.—Mouth of the Kasouga River (west of Port Alfred).

Type, a male, in the Albany Museum.

This is the first representative of the genus *Dermatopsis* Ogilby found in our region. Two species, *D. microdon* Ogilby and *D. multiradiatus* McCull. are known from Australia. From these *D. kasougae* is clearly differentiated by the much longer anal fin of many more rays, by the structure of the male genital organ, by the form of the scaling, as well as by several other features. It is actually an open question whether the present species should not be separated by full generic rank from the Australian forms, but it would be advisable to obtain more material before deciding this point.

Family MOBULIDAE.

Despite their relative abundance in tropical waters, these peculiar large rays are rarely available in good condition to the ichthyologist, partly because they are generally of enormous size and difficult to preserve, and partly because of the fear their unusual aspect inspires in ignorant persons. They are probably most inoffensive creatures.

Specimens have only twice been reported from South Africa, and there is no useful description of any complete specimen. In September 1934 the author found a large badly decayed specimen of *Mobula* species on the shore some miles west of East London, but its condition was such as to permit only of a hasty examination of the mouth, and nothing further of value could be ascertained. Recently a complete male specimen of *Mobula diabolus* (Shaw), of comparatively small size, has been obtained, and a description is appended. The peculiar formation of the branchial apparatus is too well known to merit redescription, and this has been omitted.

Mobula diabolus (Shaw).

1925, Barnard, Ann. S.A. Mus. vol. xxi, p. 86, pl. 5, fig. 2 (Figure of a stuffed specimen.) (*M. kuhli.*)

1941, Fowler, U.S. Nat. Mus., Bull. 100, vol. 13, p. 480.

Skin smooth, densely beset with fine pores. Disc 1·85 times as wide as long. Pectorals acute, more or less falcate, anterior margin convex.

The interocular distance is 5·7 in the width of the disc. The eye is 5·7 in the interocular distance. The cephalic horns are of length before the eye 2·1, before the anterior margin of the rostrum 2·5, with the total free lower margin 1·4 in the interocular distance. The greatest depth of the inferior cephalic flap is 2·4 times the eye. The cephalic flap is quite clearly differentiated from the pectorals.

The interbranchial distances are 1st, 1·5; 2nd, 1·6; 3rd, 1·9; 4th, 2·7; and 5th, 4·3 in the interocular distance. The gill slits are 1st, 3·0; 2nd, 2·7; 3rd, 2·5; 4th, 3·3; and 5th, 4·3 in the interocular.

The dorsal is small, inserted about its own length in advance of the hind margin of the disc. Length of base 2·4, height 3·6 in interocular. The tail is whip-like and smooth, without any fold, spine, or post-dorsal prominence, apparently undamaged. Its length is 2·2 in the disc width.

Mouth inferior, front margin of rostrum straight. Width of mouth four times eye diameter, 1·5 in the interocular distance. Dentition feeble, consisting of in each jaw a narrow straight transverse pavement-like band, widest medially, tapering to each end. The band in the upper jaw is slightly shorter than that in the lower, which is exactly half of the interocular. The upper band is about ten times as wide as deep, the lower more slender, almost fifteen times. In each band the teeth form a fairly flat surface, since each tooth is expanded above to an almost plane ovoid top which is extended behind into a ctenoid process, bearing 2–9 blunt points. The average tooth bears 3 points. In the upper jaw is one series bearing 8–9 points each, an abnormality, probably a coalescence. The teeth are

arranged in very oblique rows, with 10 teeth in the longest (medial) rows in the upper jaw, and 11 in the lower. In the depth of the band at the middle are in each jaw 5 teeth, those in the upper jaw being slightly the larger. There are forty-one oblique rows in the upper and fifty-five in the lower jaw. The dentition is obviously in a state of reduction.

The alimentary canal is relatively short. The gullet is about 8 cm. in length passing without expansion into a muscular L-shaped stomach, some 10 cm. in length and about 3 cm. average diameter. The inner surface of the stomach bears 21 relatively large partially furcated transverse rugae which diminish in size towards the pylorus. The latter is pouch-like and muscular, and is unique in possessing no discernible tubular connection between the stomach and the jejunal portion of the canal. The endo-pylorus consists of porous spongy tissue capable of passing matter in a state of fine division, but not even sand. Whether this is a normal condition or an abnormal stenosis may be determined only when further specimens become available for examination. At the exit from the pylorus the canal is abruptly constricted to a diameter of only 5 mm. and continues for 10 cm. to the spiral valve. The latter is fusiform, 13 cm. in length and 3 cm. in diameter at the middle. The spiral valve is relatively complex, comprising 47 complete turns. From the dilated last spiral the rectum is 5 cm. distant. The stomach contained a large amount of sand, while the spiral valve contained only a fine slime consisting of minute organisms, but no sand whatsoever. The liver is large, bilobed. The kidneys are large, much diffused and convoluted.

Colour.—More or less uniform olive-brown above, darker at pectoral apices.

Size.—108 cm. across the disc.

Locality.—Port Alfred, in the estuary, taken on a line. Bait not known, probably fish.

A male specimen, apparently immature, presented by Professor F. W. Armstrong.

This species occurs throughout the tropical Indo-Pacific.

The dentition, the nature of the branchial sieving apparatus, and the character of the alimentary structures all indicate that this fish probably feeds chiefly upon minute or easily crushed substances. The presence of sand in the stomach, and its entire absence from the post-pyloric portion of the intestinal canal, indicate that some food is probably extracted from sand which is then regurgitated. The sieving nature of the pylorus and the much constricted jejunal or duodenal region make it certain that no large particles can be assimilated. The food of this creature must consist of very small organisms, or be of such a nature as to be triturated in the stomach with subsequent regurgitation of any portions which cannot be

reduced to a paste. This would not preclude its feeding upon the flesh of fishes, or of other marine creatures.

I wish to express my gratitude to my wife for the illustrations. Also to the National Research Board for financial assistance which defrayed a part of the costs of the investigation.

Albany Museum,
Grahamstown,
April 1942.

Transactions of the Royal Society of South Africa. Vol. XXX.
Part III. pp. 279–282. March, 1947.

A NEUTRAL SOLUTION OF FORMALDEHYDE FOR BIOLOGICAL PURPOSES.

By J. L. B. Smith.

(Read September 20, 1944.)

The advantages of aqueous formaldehyde as a preservative of animal and vegetable structures are so well known as to require no repetition here. At the same time this preservative has certain disadvantages, chief of which are the result of its chemical nature. Like all aldehydes, formaldehyde absorbs oxygen comparatively readily even from the air and is thereby oxidised to formic acid. Solutions of formaldehyde attain fairly rapidly and maintain a pH of 3·5 or even of 3. When a zoological specimen, such as a fish, is immersed in this acid solution a relatively complex series of chemical changes occur which weaken the solution and damage or impair the structure. Protein and protein-degradation products neutralise a surprising amount of acid in a solution more acidic than pH 4. Experiment has shown that 100 gm. of fish flesh will during two years neutralise close on 8 ml. of normal formic acid. Also calcified and ossified structures are decalcified in acid solution. These changes continue until decalcification is complete or until all the formaldehyde has been oxidised. This renders the use of acidic formaldehyde solution over long periods for even robust specimens undesirable, and entirely prevents its employment in that condition for more delicate structures with light ossifications or calcifications which it may be desired to preserve unimpaired. Further, acid conditions favour the formation of solid polymers of formaldehyde which, alone or mixed with calcium phosphate, are often deposited on, and adhere most tenaciously to, immersed specimens, sometimes so extensively as completely to cover and hide structural features. The removal of this deposit is often impossible without very serious impairment of the material.

Since neutral or very slightly alkaline solutions of formaldehyde are free from these disadvantages, the obvious solution of this difficulty is to remove the acid by neutralisation, but agents which produce too high a pH (*i.e.* too high a degree of alkalinity) are unsuitable, since the formaldehyde may under those conditions be destroyed by undergoing self-condensation to substances of little or no preservative value. The ideal would be a buffering method whereby the solution may be maintained as nearly as

possible at neutrality, *i.e.* pH 7, or only slightly alkaline, say pH 7–8. No information about antoxidants for formaldehyde is available.

Various buffering materials for formaldehyde solutions have already been proposed. Carbonates and bicarbonates of various metals have been suggested, but Atkins (J. Mar. Biol. Ass., N.S., 1922, xii, p. 792) has shown that all are unsatisfactory, *e.g.* he states that formalin distilled with solid $MgCO_3$ gives a distillate of pH 4·4. Also carbonate neutralisation involves the more or less continual evolution of carbon dioxide, which may be a very serious disadvantage, while formaldehyde solutions neutralised by a strong alkali apparently re-oxidise with great ease.

Atkins (*loc. cit.*) has suggested the use of borax, in such amount (5–10 gm. per litre) as to produce a solution of pH 8·5–9·0. This is apparently the most satisfactory method hitherto proposed and has been widely adopted. The method involves the use of indicators to show whether the desired pH has been attained. It suffers from the further disadvantage that for the buffering to be automatic over a long period, so much borax must be added that the alkalinity of the solution is stepped up to a point where self-condensation of the aldehyde may become marked.

A solution with a tendency to acidity due to autoxidation such as that of formaldehyde may be buffered near neutrality either by thus adding the salt of a weak acid and a strong inorganic base such as borax, or by the addition of excess of a very weak base. No suitable soluble inorganic bases are available. Amongst organic bases the choice is limited to those soluble in water, and still further to those whose presence in a preserving medium would not be undesirable. One such is hexamethylenetetramine (or hexamine) which results from the interaction of formaldehyde and ammonia as follows:—

$$6CH_2O + 4NH_3 = (CH_2)_6N_4 + 6H_2O.$$

It is crystalline, and easily soluble in water, giving a feebly basic solution (pH 7·6–8·0 over a wide range of concentrations).

Its addition in moderate amount to an old formaldehyde solution of pH 3 alters that immediately to pH 7·6–7·8 by the basic character of the hexamine alone. Experiments covering five years have shown that formaldehyde solutions over a wide range of concentrations may be maintained at pH 7·0–7·8 by the addition of hexamine. It seems likely from observations made that autoxidation of the formaldehyde in the presence of hexamine at this pH range is less than normal, *i.e.* that it functions not only as a weak base but also as an antoxidant.

Hexamine is in normal times available in quantity and relatively inexpensive, and proves to be an excellent buffering agent for formaldehyde solutions. These may be maintained so slightly alkaline that polymerisation does not occur and decalcification of material is not possible.

Professor J. Omer-Cooper of this College has tested formaldehyde solutions so prepared for use with histological material, and has reported them to be satisfactory for even the most delicate structures. For the preservation of fishes the solution has been found excellent, and specimens are beautifully preserved with no trace of surface deposit.

In preparing fresh solutions of buffered formaldehyde it is recommended for ordinary purposes that 200 gm. hexamine be added to each litre of formalin solution, *i.e.* 2 lbs. hexamine to 1 gallon formalin. (By formalin is meant 38–40 per cent. formaldehyde solution.) This solution may be diluted as desired. Solutions prepared in this fashion are at about pH 7·8.

If hexamine be unobtainable, the same result may be achieved by the addition of ammonia, with, however, considerable effective loss of formaldehyde since hexamine is formed from it. Concentrated ammonia solution S.G. 0·9 may be employed. It should not be added direct to the concentrated formaldehyde solution as the reaction is too violent. The formalin should first be diluted, and the ammonia then added with caution and constant stirring for the stronger solutions.

The following table shows the quantities recommended:—

Per cent. Formaldehyde desired:	3	4	6	8
38/40 Formalin vol., litres:	1	1	1	1
Add Water, litres:	$6\frac{1}{2}$	6	5	3
Stir in 0·9 S.G. Ammonia:	200 ml.	150 ml.	125 ml.	100 ml.

Estimations made with solutions of considerable age prepared by either method indicate that if kept in fairly good containers, with average handling and exposure to air, they should maintain both strength and practical neutrality for many years.

For special purposes solutions almost exactly neutral may be prepared. For this purpose add 3 per cent. hexamine by weight to the diluted solution and mix thoroughly. Remove 50 ml. and titrate with a normal solution of formic acid (5 ml. pure formic acid diluted to 100 ml.), using a suitable internal indicator (B.D.H. Universal is satisfactory), until the desired pH in the range 6·8–7·2 is attained. The amount of formic acid to be added to the main known bulk of the solution may then be calculated.

In treating old dilute solutions of formaldehyde, they should be transferred to some large vessel and well mixed. Add with stirring 10 ml. 0·9 S.G. ammonia diluted to 50 ml. for each litre of solution. The solution will on an average then be about pH 7. (Litmus test paper or an external indicator may be used if desired, but is not essential.) Then add 15 gm. hexamine for each litre of solution and mix well. For ordinary Museum purposes it is as effective merely to add 30 gm. (1 oz.) hexamine for each

litre of dilute formaldehyde solution. In these latter cases it is as well to add some fresh formalin to replace that lost by oxidation.

It may be noted that hexamine neutralises acids, beyond its feebly basic nature, also by reacting with them to produce formaldehyde, as follows:—

$$(CH_2)6N_4 + 2H_2O + 4H_3O^+ = 6CH_2O + 4NH_4^+ \quad . \quad . \quad (1)$$

In concentrated solutions at the ordinary temperature this reaction is reversible at pH 4–5, *i.e.* formaldehyde solutions react with ammonium salts to give an acid solution of pH 4–5. In concentrated neutral solutions of formaldehyde therefore reaction (1) plays no part in maintaining neutrality. In more dilute solutions of formaldehyde, however, low concentrations of ammonium salts appear unable to render the solutions acidic. From observations on solutions kept for over four years, it appears that in dilute formaldehyde solutions hexamine gradually destroys acidic conditions up to pH 6 by reaction (1). In such solutions therefore hexamine likely maintains relative neutrality by threefold action—as a base, as an antoxidant, and by removal of acid according to reaction (1). It will in that event not only maintain neutrality but also replace any formaldehyde lost by oxidation.

I wish to express my gratitude to the National Research Board of South Africa for a grant which defrayed part of the costs of this investigation.

Rhodes University College,
Grahamstown,
September 1944.

INDEX TO VOLUMES I and II

Volume I ends at page 300

VALID SCIENTIFIC NAMES are in plain capitals.
Page in heavy type shows a description on that page.
Synonyms and Malidentifications are in italics.
An asterisk shows that there is an illustration on that page in the text.

Volume I ends at page 300

Volume I ends at page 300

J. L. B.
SMITH

ICHTHYOLOGICAL PAPERS

1931-
1943

Vol. 2

J.L.B.S.
Inst. Ich.